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On a Letter to Benjamin Franklin

By PARK BENJAMIN

In view of the bi-centennial anniversary this month of Benjamin Franklin's birth, the following reflections on a letter to him, by Dr. Park Benjamin, are of particularly timely interest. They relate especially to Franklin's electrical achievements, his historical lightning experiments, at Philadelphia in 1752, and the effect of what he had done on philosophers elsewhere.—The Editor.

DR. FRANKLIN'S HISTORICAL EXPERIMENT IN THE SUMMER OF 1752

From an Old Engraving

THERE has lately come into my hands a letter yellow with age, which bears neither date nor signature. The writer begins with an expression of doubt, "If anything which happens in this foolish kingdom deserve your attention," and ends with the remark that certain persons, revealed only by initial letters, "will tell you who I am and how to direct to me." Its contents indicate that it was written in the fall of 1777. An endorsement at the bottom of its final page shows that it is "from Dr. Berkenrode."

The recipient, in whose hand writing the endorsement is made, and from among whose papers it seems at some time to have strayed, was Benjamin Franklin; and it conveys to him the intelligence that his greatest discovery, which filled the whole world with wonder and admiration, has been discarded by his discarded King. "The pointed conductors on Buckingham House," it says, "are already taken down." Of the events which led to this communication, I propose now to tell the story:—

In the fall of 1748, Franklin retired from business in order to devote himself to the study of electricity. He sold his newspaper, almanac and printing house to David Hall, and, with a fortune sufficient to provide for his modest wants, turned from the cares of business to enjoy his long wished-for "leisure to read, study, make experiments and converse at large with such ingenious and worthy men as are pleased to honour me with their friendship or acquaintance."

The letters to Collinson, in which he had propounded his famous electrical theory and his analysis of the Leyden jar, had already been written. He was now advancing toward even broader conceptions, and the experiments which he and Kinnersley were making were multiplying the proofs and forcing upon his mind the conviction that the greatest conception of all was in fact well founded, and that lightning and electricity were one. Late in 1749 he recounts to Collinson the particulars in which the electrical fluid (as he terms it) and lightning agree, and among these he notes that the fluid of his jars and globes is "attracted and drawn off by points." It seems to him that if it can be shown that lightning also possesses the property of being attracted by sharp conductors, if it will come out of a cloud to a metal point as the electrical fluid seemingly comes out from the jar or globe, then the fluid in the cloud and that in the glass must be identical.

At first he seeks to devise an experiment which will substantiate this idea, by an analogy. He tries to reproduce the conditions of the electrified cloud and the attracting point in miniature. After his simple and homely fashion, he arranges a brass scale-pan, so that it will swing over a needle placed beneath it, and electrifies the pan. The experiment succeeds; the pan discharges on passing over the needle, and the most important of all his letters to Collinson is despatched.

In it is proposed the preservation of houses, churches and ships from the stroke of lightning, by fixing on the highest points of them "upward rods of iron, made sharp as a needle, and gilt to prevent rust, and from the foot of these rods a wire down the outside of the building into the ground." The proposal is followed, with philosophical caution, by the question, "Would not these pointed rods draw the electrical fire out of the cloud before it came nigh enough to strike and there secure us from that most sudden and terrible mischief?" That is as far as he would then go,—a simple proposal and a query as to the results.

But there was less of the calm philosopher in Collinson, staid Quaker though he was. To him the idea "flamed amazement." He hastened to the Royal Society, of which he was a member, and laid the letter before it. The Society laughed at him. The whole notion was too absurd, too visionary for the trained

Drawn by C. N. Cochin, 1777 Originally Engraved by A. H. Ritchie

minds which, at that time, were struggling with the intricacies of human deformities and the delusions of "medical electricity." The rebuff only increased Collinson's determination that Franklin's letters should be published. He applied to Cave, the publisher of the "Gentlemen's Magazine," and Cave, while refusing them a place in those dreary pages, at last after much deliberation, decided to print the collected letters in a separate pamphlet, with the understanding that all profits, which might be derived therefrom, should come solely to him.

Meanwhile, Franklin's electrical achievements were not only astonishing his neighbours in Philadelphia, but the fame of them had spread throughout the American colonies. His house was a rendezvous for curiosity seekers and invalids, the latter besieging him in the hope of gaining relief from the pangs of rheumatism through the powerful shocks from his cascade battery. Besides, the electric motor which he and Ebenezer Kinnersley had contrived was a wonderful thing. He had set electricity to work to turn a roasting spit, and there was also the "electric spider" and the "magic picture" and the "animated fish," not to mention many another odd conceit which the genial philosopher, who knew human nature so well, had devised to make the knowledge that he had gained attractive and easy to others.

During all this time, Franklin was puzzling how to convert his little laboratory experiment with the electrified scale pan into one of grander proportions, which would enable him literally to grasp the lightning. He saw no way of getting near enough to the thunder cloud. The discovery of the properties of hydrogen gas by Cavendish, which led to the first attempts at aerial navigation, was still in the far future. The meeting houses of the Quaker town had no pinnacles; and, in fact, the whole province of Pennsylvania was without a steeple. He tried hard to revive the lottery which was to provide the funds to build a spire on Christ Church in Philadelphia, but the project, despite his efforts and influence, enlisted but little popular interest.

The summer of 1752 found the experiment still unmade and Franklin meditating a return to political activity. Then there came across the Atlantic, news which startled him. His printed letters to Collinson had fallen into the hands of the great French naturalist, De Buffon, whose master mind had not failed to grasp the import of the discoveries which they described, and who had immediately caused the book to be translated into French. The keen Gallic philosophers, ever on the alert for the curious and novel in Nature, had discussed the Franklinian experiments at their meetings, and the interest had grown until all intelligent people throughout France were talking of them. The King commanded the experiments to be repeated in his presence. The philosophers exhibited to him the strange contrivances which had already astonished the Philadelphians, but hesitated to attempt before him a trial of the lightning-attracting power of the pointed rod. That, they essayed in private, D'Alibard erecting an iron wire 40 feet high, in his garden at St. Germain, and De Lor, a rod, 90 feet high, in Paris.

From both of these rods, sparks had been drawn during thunder storms, and people had received severe shocks from them. The intelligence gave to Franklin renewed vigor. He saw at once that these experiments, although on a greater scale than his own, were still inconclusive. The rods ended near to the earth. They did not extend to the thunder cloud—and in the latter he believed the lightning to lie. How was the cloud to be reached?

Then there flashed across his mind the idea of a kite,—a kite which would carry his pointed rod into a low-lying thunder cloud, so that if the lightning were electricity, it would come down to him on the kite string, just as the electric virtue from Stephen Gray's rubbed glass had run over hundreds of feet on a pack-thread line, and, better still, as Dufay had shown, thirty years before, over wet pack thread. So he made his kite, as usual out of the first things literally most conveni-

ently at hand,—his silk handerchief and two sticks, placed crosswise and fastened to the handkerchief at its corners.

It was a square kite*—and not the coffin-shaped affairs shown in the story-book pictures. To the upright stick of the cross he attached his pointed rod,—a sharp wire, about a foot long,—and provided himself with a silk ribbon and a key; the ribbon, to fasten to the string after he had raised the kite, as some possible protection—how much he did not know—against the lightning entering his body, and the key to be secured to the junction of the ribbon and string, to serve as a conductor from which he might draw the sparks of celestial fire,—if it came.

When the thunder storm broke, he went out on the open common near Philadelphia, and faced death,—faced the tremendous power of the lightning stroke, before which all people of all ages had quailed in terror; faced what most of the world then believed to be the avenging blow of an angered God. True, he believed that electricity and lightning were the same thing, and therefore had no different properties or effects; but he did not know it.

The best existing theory which accounted for electrical phenomena at that time was his own. The laws of electrical conduction or resistance, now so familiar, were not even suspected. Who could predict that the lightning would obey any law? Besides, he had produced tremendous shocks with his Leyden jars in series, and had killed birds with them. More than that, he had been terribly shocked himself by the same means, —stunned into insensibility and nearly killed. He had said, again and again, that an electric shock, if strong enough, would blot out life, though without a pang. If his idea was correct, if his conviction was true, he was now about to face an electric discharge besides which that of the most powerful man-made batteries would seem weak and insignificant.

All the world knows what happened. The kite soared up into the black cloud, while the philosopher stood calmly in the drenching rain watching the string, until finally he saw the little fibres of the hemp raise themselves. Then without a tremor he touched his knuckle to the key,—and lived. For the spark crackled and leaped to his finger as harmlessly as did that from his old familiar electrical machine, and allowed him to charge his jars with it with the same impunity.

He sent the story of what he had done abroad, without a particle of trumpeting. He was not a discoverer for revenue. No stock markets awaited the announcement of his claims; no newspapers stood ready to blare forth his achievement in the interest of the money jugglers. His own narrative barely fills one of the little columns of the "Gentlemen's Magazine" for October 19, 1752 (Cave meanwhile having graciously thought better of him), and it has at its end only the initials B. F. Conceive of a "modern wizard" retiring not only into such anonymity as this, but even failing to state that he had made the achivement!

"It may be agreeable to inform the curious," begins this philosopher, so out of harmony with modern ideas, "that the experiment has succeeded in Philadelphia, though made in a different and more easy manner" from that followed by the Frenchmen. Imagine a "modern wizard" thus impersonal!

And the description is brevity itself. It would not fill half the present printed page. It closes with the words, "From electric fire, thus obtained, spirits may be kindled and all the other electrical experiments be performed which are usually done by the help of a rubbed glass globe or tube; and thereby the sameness of the electric matter with that of lightning completely demonstrated." This is the way in which one of the grandest discoveries ever made by man was announced by the greatest philosopher and discoverer that America has ever produced.

Thereupon kites went up into the air over Charleston, over Turin, over Paris and over London. The philosophers of America, of Italy, of France and of England were following the newly blazed path. Here and there a rod showed itself over a roof, especially in Norfolk, Va. The people of Europe rose to excited interest, so excited that it alarmed the Church. The pulpits, when they did not fulminate against the awful impiety of seeking to ward off the chastening flame of the Almighty, anathematized the heretics who denied this same impious efficacy to the consecrated bells. But Galileo's rack was in the scrap heap, and no one feared the rekindling of Bruno's fagots.

Then Franklin, having his mind at

A PORTRAIT OF BENJAMIN FRANKLIN, BY MARTIN

Engraved by T. B. Welch. In possession of The American Philosophical Society.

* I append an old engraving made early in the present century, which shows the kite of this shape. See page 1.

peace through his great accomplishment, and seeing that Kinnersley, the enthusiastic, was faithfully spreading electrical knowledge by giving lectures from Massachusetts to South Carolina, went back to his politics, and negotiated provincial loans in Boston, and tried hard to dissuade Braddock from his ill-fated expedition, and so pursued the useful tenor of his way, until the leading strings of the colonists began to chafe. And when at last "our gracious proprietary," as he once called the Penn owners of Pennsylvania, became oppressive, he threw his politics and his financiering and his electricity all to the winds together, and went to England to battle for the God-given rights not only of the people of Pennsylvania, but those of Massachusetts and Maryland and Georgia. When he got there the philosophers honoured him, and deemed it a marvel that such goodness could come from the American Nazareth.

While the presence of Franklin in England aroused renewed interest in his discovery, the lightning rod had by no means yet received the full sanction of the English philosophers. There was grave doubt concerning its efficacy. The great national edifices were unprotected by it. Worse still, there was an undefined fear of it, because of the death of the Russian philosopher Richmonn, who had attempted to measure the strength of a lightning discharge coming over a rod, and had been killed in the attempt, owing to his failure to provide a ground connection. Its strongest English adherent was perhaps John Canton; but in 1762 he had turned to other investigations.

It was in that same year that intelligence arrived in England that the "Harriot" packet had come into New York Harbour, severely damaged by lightning, with her masts split, her boats stove, her compasses ruined, and her rigging burned. However much the British merchant might venture to risk his storehouse on shore, when it dawned on him that the lightning was a real menace to his commercial prosperity, through the peril in which it placed his ships, this was too sharp a touch upon his pocket nerve to be overlooked, and he soon acquainted the Royal Society with his desire for definite knowledge of the reputed new safeguard.

Dr. William Watson, easily first among English scientists of the day, took up the matter and proposed that ships' masts should be fitted with conducting wires, leading to the water, at the same time calling attention to some recent cases of damage by lightning to buildings, and especially proposing that the great powder magazine, then being erected at Purfleet, should be at once provided with lightning rods. Although the quantity of gun powder stored at Purfleet was large, this proposal met with no immediate response.

Two years later, the steeple of St. Bride's Church in London was struck and shattered, and a number of houses in Essex street were seriously damaged. Popular appeals to the Royal Society were renewed. The unexpected effect was to develop a new and bitter antagonist to the pointed rod, in the person of Benjamin Wilson. Wilson had been a house painter, and had become affluent through a contract for painting the government buildings. He studied electricity many years earlier, and, like most philosophers of his time, had evolved his own private theory to account for it. He had also written, in 1746, a treatise on the whole subject, which is apparently the earliest of its kind, and contains much misinformation.

The use of the pointed rod Wilson violently opposed, claiming that, so far from protecting buildings, it invited the lightning to them. He insisted that "buildings should remain as they are at the top; that is, without having any metal extending above them, either pointed or not; and by way of a conductor, he proposed fastening on the inside of the building 'a rounded bar of metal communicating with the ground.'" If the building had any iron vane or other ornament, he was willing that the rod should be connected to that. But, ultimately, his contention reduced itself to the essential requirement of a conductor having a blunt or knobbed apex. The suggestion that the pointed rod actually invited the lightning to places where it would not otherwise go, proved to be exceedingly disquieting, not only to the philosophers, but to the anxious public, to whose already keen apprehensions the element of doubt was thus added. The Royal Society became at once rent into two hostile factions; one pressing upon the nation the urgent need of protecting its great buildings by the pointed rod; the other as strongly insisting upon the peril which would inevitably follow the adoption of such a course.

Meanwhile, Wilson had declared that the great Cathedral of St. Paul was unprotected, and had advocated the use thereon of conductors erected according to his plan. But nothing was done until 1769, when the Dean and Chapter of the Cathedral, finding renewed cause for fear in still later injuries caused by lightning to buildings, formally applied to the Royal Society for an authoritative opinion as to the best mode of protecting the great church.

The society appointed a committee, composed of John Canton, Edward Delaval (an electrician of some prominence), Benjamin Franklin, Benjamin Wilson, and Dr. Watson, thus including in it the foremost advocates of the opposing theories. All agreed that the Cathedral was in danger, that its many metal projections were not connected properly to the ground, and they pointed out the especial peril which menaced the stone lantern above the dome. The report, however, was a compromise, with a leaning towards the views of Wilson. It did not advocate sharp rods, but recommended large conductors to be connected to the already existing upward metal projections on the building. Thus the controversy was left practically unsettled.

Meanwhile the wars in which England had been engaged had caused an immense accumulation of gun powder at Purfleet. The fears of wholesale explosion increased. There was not only the danger of widespread destruction of life and property in the neighbourhood of the great magazine, but apprehension that the loss of so much powder might seriously impair the military resources of the nation. The Government then appealed to the Royal Society, and again a committee was appointed to consider the matter, the members being Henry Cavendish, John Robertson, Dr. Watson and Franklin. This time, Franklin went into the conflict with his whole heart, and exhibited to the committee experiment after experiment, describing them and presenting his arguments with that perfect terseness and clearness which, before him, had characterized the writings of Charles Dufay, and, after him, those of Michael Faraday.

To Wilson's objection that the pointed lightning rod invited lightning, he said:—"Were such rods to be erected on buildings without continuing the communication down into the moist earth, this objection might then have weight; but when such particular conductors are made, lightning is invited not into the building but into the earth, the situation it ends at." To the sneer of his opponent that his theory rested only upon "little" experiments, he replied that although pointed rods had been used in America for twenty years,

only five of them had been struck, and that in every one of these cases the "lightning did not fall upon the body of the house, but precisely on the several parts of the rods, and, although the conductors were sometimes not sufficiently large and complete, went ever into the earth without any material damage to the building." His arguments prevailed and the committee formally recommended pointed rods.

Wilson attacked the report fiercely. He even twitted Franklin with the fact that, although he had been a member of the committee which had considered the protection of St. Paul's Cathedral, that committee had not specifically recommended pointed rods, thus trying to convict Franklin of inconsistency because the earlier committee under his (Wilson's) own influence had rendered a compromise report. But the new committee stood unmoved. It gravely considered all of Wilson's objections, and then advised the Royal Society that it saw no reason to vary from the conclusions already expressed. Franklin's victory was substantial and complete.

The advocates of the sharp rod now took heart of grace, and, chief among them William Henley, by experiments as well as by the careful gathering of facts, demolished Wilson's contention thoroughly and in detail. The mooted question seemed to be settled at last. The pointed rods went up on the great magazine at Purfleet and on the king's palace.

Meanwhile the affairs of the American Colonies had reached a crisis. Great Britain had determined upon coercion. Franklin's efforts had failed, and he left the country. His departure was the signal for the reappearance of the extinguished Wilson. Arguments which could not prevail against Franklin, the philosopher, might, he hoped, prove more potent when directed against Franklin, the rebel.

Fortune gave him his opportunity. In the spring of 1777 an unimportant building at Purfleet was struck. the damage was trivial, merely a few pieces of stone and brick being knocked off the coping of a wall. This was Wilson's chance. He insisted before the Royal Society that the pointed rods had utterly failed to perform their office, and demanded that they should be rejected as "threatening us every hour with some unhappy consequence." Then he played his trump card. "It is your very great concern," he says, "that I am obliged to take notice in this society that a house which is of the first consequence in this kingdom has pointed conductors also fixed on it; I mean the King's, our most gracious patron's and benefactor's," and without waiting for the society's judgment in the matter he appealed over its head directly to George in person.

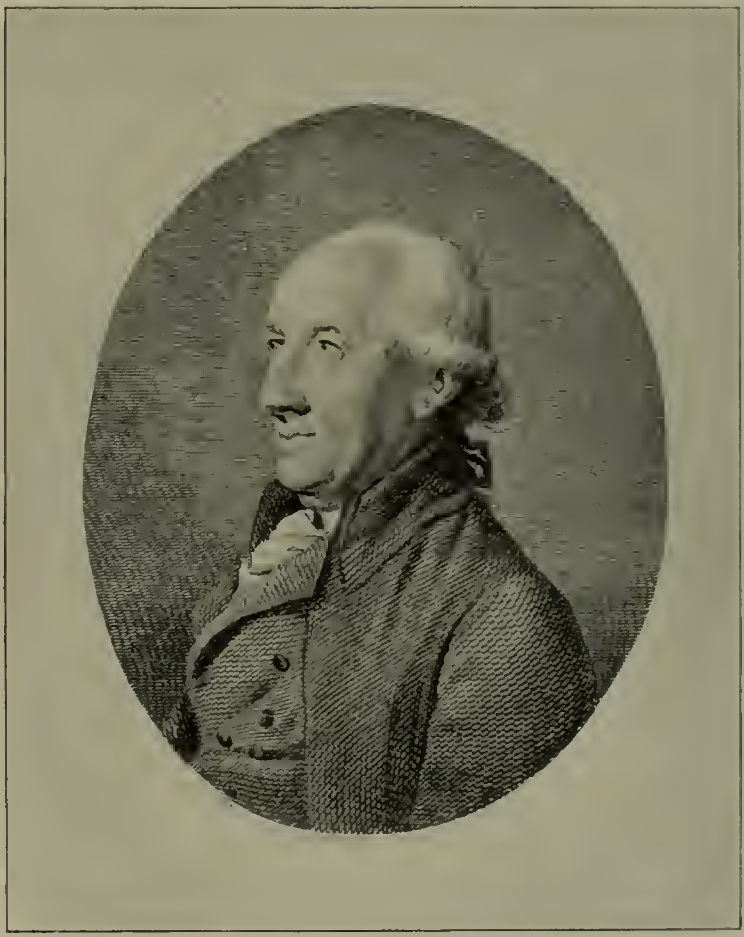
The Royal Society, while yielding nothing in loyalty, had never acquiesced in the doctrine that the divine right of kings involved either omniscience or infallibility in matters of science. King Charles II. had destroyed the possibility of such a notion at the very outset of its career. It had neither forgotten the eager student of chemistry and willing learner who claimed for himself no more than the simple privilege of membership, nor the swift and stinging rebuke with which the King met its refusal to admit to its aristocratic company, John Graunt, tradesman. But it was a far cry from witty, cynical, intelligent Charles to slow, obstinate George.

Whatever the Royal Society or the American colonists or any others of his liegemen might think, George III., before all, considered himself as the father of his people and claimed obedience to him to be their first law. Failure to assist him could only be the acts of "bad men, as well as bad subjects," and "assistance" meant acquiescence in whatever doctrines, opinions, theories or conclusions, political, scientific or otherwise, an inscrutable Providence might permit to find lodgment in his brain. At about this time he was hating Americans with especial fervor, and including everything American in the circle of his hatred.

The pointed rod was essentially an American idea, a seditious, rebellious, American conceit, and his sturdy British heart responded to Wilson's plaint so warmly that he and little Queen Charlotte and the Princesses all came to the Pantheon and graced by their presence the exhibition which was to bring confusion to the errors of the bad subject and exalt the truth as defined by the loyal house-painter.

The old letter before me tells what Wilson did. Not as fully, of course, as was afterwards recorded in the annals of the Royal Society, but with ample detail for the information of Franklin. There is, besides, a freshness about the narrative of the eye witness, which the dry official synopsis does not possess. Wilson was undeniably ingenious, and he was determined that his experiments, this time, should lack nothing in magnitude. He wanted a thunder cloud which would give, on demand, a lightning stroke; but as a real cloud could not be conveniently imprisoned in the Pantheon, he invented an artificial one.

He obtained from the Tower authorities a great number of drums, covered them with lead foil, and bound them together in a huge cylin-



DR. BERKENHOUT

From The European Magazine, October 1, 1788

der 155 feet long, which he suspended by silken cords below the cupola. From the ceiling of the cupola to the drums, he carried, up and down, some 1600 yards of iron wire, each line of wire being kept apart from the other lines, so that the entire space between cupola and drums was thus filled. "All this," says the letter, "is intended to represent a thunder cloud,"—and it certainly is a very good imitation of one. The cloud was electrified from a double-cylinder frictional machine, and I leave Dr. Berkenhout to tell the rest in the words in which he told it to Franklin.

"Now as this cloud could not be made to pass with proper celerity over a house, the house is made to pass under the cloud. A wooden model of the powder magazine at Purfleet with leaden spouts, etc., is held by a loop at one end of a groove on a long table under the drums. To the other end of the house is fastened a rope, to the end of which hangs a weight, the rope running on a pulley. The cloud is then charged by twenty turns of the wheel, and a pointed conductor, of the same proportioned height with that at Purfleet, being placed on the house, the loop is slipped, and the house in passing under the cloud discharges it with a loud snap and considerable flash. The same being repeated with a conductor with a knob, the cloud is not infallibly discharged, tho' sometimes it is. Hence, he concludes that thunder clouds will generally pass harmless unless invited by a pointed conductor."

And the King was convinced. The pointed rod was not only a republican invention, but one expressly designed to injure his Majesty. He ordered it removed from Buckingham Palace at once, and the triumph of Wilson was absolute.

But the Royal Society remained ominously silent. "What the Royal Society thought of it I do not know," says the writer of the letter. The silence worried George. The members were his subjects, and his opinion should be their opinion. They might regard Wilson's show as claptrap as much as they chose, but for them to differ from his conclusion was disloyal and intolerable. Whenever he was thwarted he was agitated, and this time his agitation was akin to that which he felt when Pitt, from his place in the House of Commons, rejoiced that America had resisted the Stamp Act.

He sent for Sir John Pringle, the president, and took him severely to task. The scene of Charles I. and the speaker was re-enacted with variations. Sir John sturdily replied that he could only speak the sentiment of the society which was adverse, and that scientific truth rested on fact and not on opinion. George dismissed him with a savage lecture, and, finding the society still recalcitrant, stripped him of his office.

The letter meantime had found its way across the Channel, and was in the hands of the venerable plenipotentiary of the colonies to the French Court. One can easily imagine the amused smile which crept over his face as he read it. His comment is historical.

"The King's changing his pointed conductors for blunt ones," he said, "is a matter of small importance to me; if I had a wish about them, it would be that he would reject them altogether as ineffectual. For it is only since he has thought himself and his family safe from the thunder of Heaven that he has dared to use his own thunder in destroying his innocent subjects." Then he endorsed the name of the writer—which the writer had not dared to sign—at the end, and laid the epistle aside to await the outcome of events. They have all happened long ago.

Berkenhout,—not Berkenrode, as Franklin writes it,—remained a court parasite until he was sent to America in 1778 with the Commission for restoring peace to the Colonies, the intervention of which the Colonies contemptuously rejected. He was detained in New York but, surreptitiously making his way to Philadelphia, was implicated in an attempt to bribe members of the Congress, for which that body imprisoned him and finally shipped him back to England. "For having committed himself to the mercies of an Enraged Republican Congress," says his biographer, "his grateful country rewarded him with a pension."

Mr. Benjamin Wilson's knobbed conductors do not now rise above the dwelling of the gentle and gracious Queen, whose friendship for the posterity of King George's rebellious children has so often found timely manifestation. The society which Wilson flouted in the sunlight of royal favour had its revenge in its recorded estimate of him which must stand imperishably. "It was by his obstinacy and improper conduct," says its historian, "that he introduced those unhappy divisions which had so unfortunate effect upon the Royal Society, and which were so disgraceful to the cause of science and philosophy."

Such is the story which this letter of bygone days recalls. Of him who broke its seal, nothing can here be said which can add to the veneration and gratitude which he commands not only from his countrymen, but from all humanity. In these days of over-feverish activity, even in the quest of scientific truth, when invention is too often without philosophy, for which there is no room amid the jarring and sordid interests which prevail, it is good and wholesome to turn back to the doings of this American philosopher. He was our first,—he is still our greatest,—electrician.

The New Building of the Engineers' Club

THE foundation stone of the new building of the Engineers' Club, on West Fortieth street, New York City, opposite Bryant Park and the new Public Library, was laid on December 24, at 2:30 P. M. by Mrs. Andrew Carnegie, whose husband declared the task well and truly done. The ceremony was quite informal, but the club was well represented by its officers and committees, including President W. H. Fletcher and Past-President John C. Kafer. The architects, Messrs. Whitfield & King, were also present.

The party were enabled to inspect the building, now up to the ninth story in the steel work and to the third in marble and brick casing. The records deposited in the stone included a Bible of 1905, a club book of 1905, copies of "The Herald," "Tribune," "Sun," and "Times" of December 23; a copy of the certificate of incorporation; a booklet of the old clubhouse at 374 Fifth avenue; a half-dollar, a quarter-dollar, a ten-cent, a five-cent and a one-cent piece; a card of W. L. Crow, the builder; a copy of Mr. Carnegie's letter of gift to the Engineering Societies and the Engineers' Club; a chronological history of the club; a list of members elected since the publication of the club book this year; a list of the incorporators of the club; the programme of competition for the selection of architects for the two buildings; and floor plans of the new house.

The deterioration of coal in the open storage yard of the Boston Edison Electric Illuminating Company is stated by Charles H. Parker to be 6.5 per cent. Taking into consideration the fact that the coal contains 2.2 per cent. more moisture in winter than in summer, owing to the amount of snow and ice that is brought into the station with it, the net loss by weathering is placed at 4.3 per cent.

Gas Power for Electric Railways

By J. R. BIBBINS

Extracted from a Paper Read at the Last Meeting of the American Street Railway Association

THERE are three important characteristics for a prime mover for steam railway work, viz., close speed regulation, considerable overload capacity, and high economy over normal ranges of load. Entire success, however, may be attained only through the harmonious working of the entire plant, whether steam or gas; in fact, in the case of the latter successful operation may be attributed in almost equal proportions to the gas and power generating sections of the plant. Unfortunately, it is true that the faults of the one may all too readily be charged to the other; yet a careful study of practical operation shows the futility of such distribution of responsibility.

A generating plant for railway service, especially for suburban and heavy-duty work, must be unusually responsive to sudden power demands; to accomplish this the two sections of the plant must be peculiarly well fitted to operate together under normal load conditions. The plant should also be quick in starting, capable of standby for long periods without excessive loss of heat, and, above all, should show high all-day fuel economy. This is admittedly a formidable list of requirements; yet we may not dodge the issue with gas power any more than with steam.

ADAPTABILITY OF GAS ENGINE AND PRODUCER PLANT.

Does gas power fulfill in every respect the conditions imposed? As the old and much abused saying goes, "The proof of the pudding lies in the eating thereof." This phase of the subject may best be approached through comparison, step by step, with steam power, with which every one is familiar. This is done not for the purpose of discrediting the latter, but merely to obtain a clearer conception of the points involved.

Primarily, the fitness of the gas engine for driving electrical machinery must be demonstrated beyond question. This has repeatedly occurred in practice, examples of which will be cited later. With certain cylinder arrangements rotative speeds, uniformity of turning moment, and speed regulation are as well suited to both D. C. and A. C. generator driving as the standard cross-compound steam engine. The gas engine is as simple a machine to operate; its efficiency as a mechanism is as high, and as a heat motor far higher, and its overload capacity is largely dependent upon the dimensions of the customer's purse. Assuming, then, that the gas engine is already established in its position, we come to the gas generating plant, which, in many respects, is the crucial point of the system, except in special localities where natural gas is available at reasonable prices.

THE PRODUCER.

The future of the gas engine in its general application depends largely upon the development of a producer gas system especially suited to the use of low-grade bituminous coal. Anthracite producers have already reached a high state of perfection, are reasonable in price, simple to operate, and are usually unencumbered with much auxiliary apparatus. They do not deteriorate rapidly, and generally show an efficiency considerably higher than the best steam boiler and furnace, viz., 75-80 per cent.

The ideal bituminous producer is yet to come, viz., one in which the volatiles are completely converted into fixed gases without serious loss and without complication of the operating system. There are a number of makes now on the market intended to be used with bituminous coal, but when the gas is to be used in engines they are attended with special, and often complex, cleaning apparatus for the removal of suspended impurities. The efficiency of bituminous systems is also generally lower than anthracite, not only owing to the fact that some of the valuable distillates are lost, but on account of the distillation of volatile matter requiring heat for its accomplishment. Present types, however, sometimes exceed 70 per cent. efficiency, which rivals that of the best boiler plant.

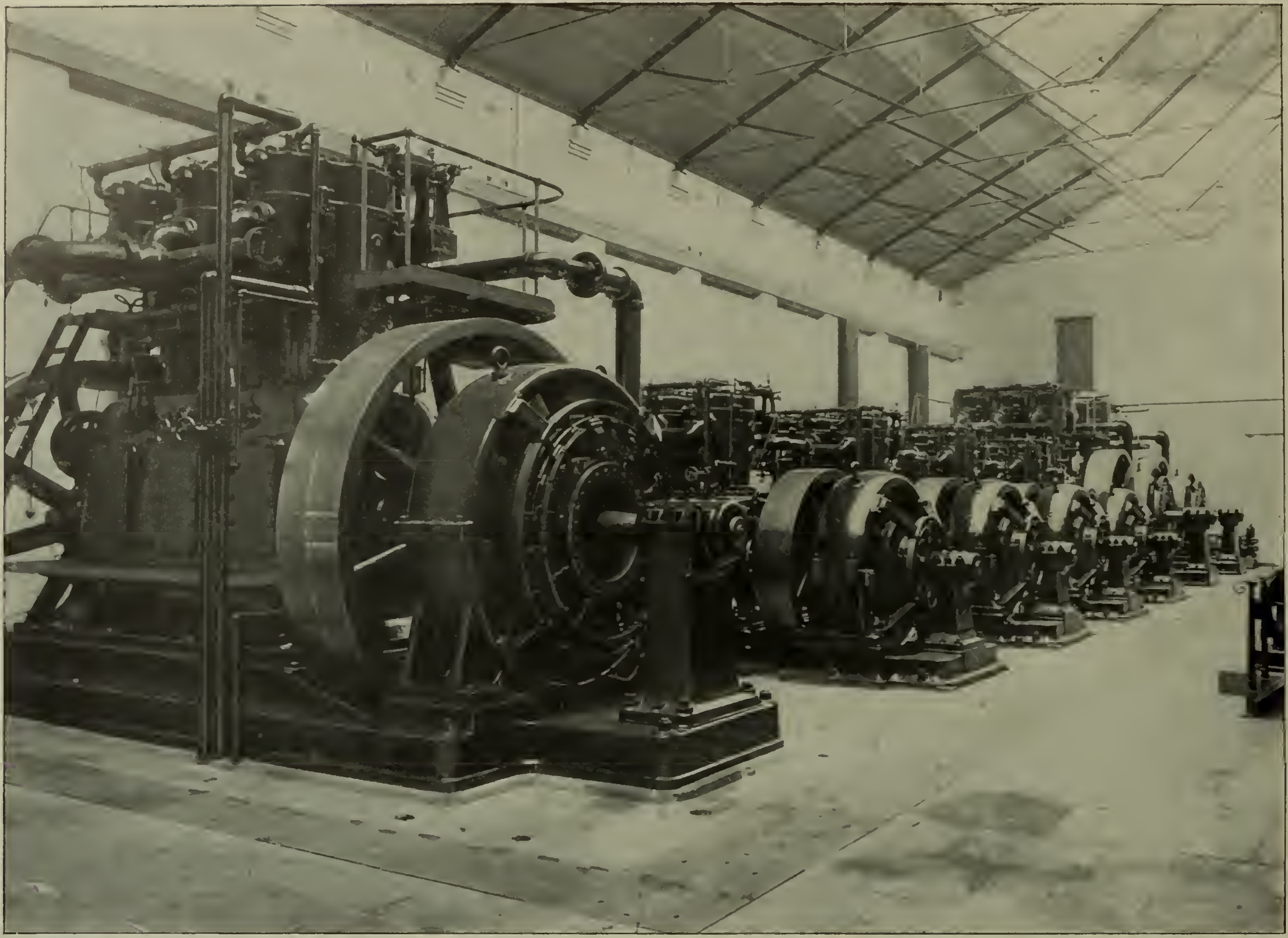
FUEL ECONOMY

In actual running fuel consumption, gas power presents its most striking advantage over steam. It is difficult to obtain statistics truly comparative in every respect. Some data, trustworthy in the aggregate, are available from the tests conducted during the past year at St. Louis by the United States Government. Table I. gives a resume of these tests, covering 17 different grades of coal, all of bituminous character. The most remarkable result is that the poorest grade coals and even lignites are entirely suitable for producer work. Thus, Montana, North Dakota, and Texas lignites, averaging only 8242 B. T. U. per pound (11,400 dry) yielded a gas of 169 B. T. U. per cubic foot,—a gross producer efficiency of 66 per cent. and a duty of 2.5 pounds per K. W. H. dry, or 3.6 pounds per K. W. H. as fired. The best coals (West Virginia) gave an actual duty of 1.57 pounds per K. W. H., and the poorest $3\frac{1}{4}$ to $4\frac{1}{2}$ pounds as fired. The average of the 17 tests showed a plant duty of 2.2 pounds per K. W. H. dry, or 2.5 pounds as fired.

It is fortunate that the government extended these tests to embrace steam* as well as gas power. Comparative economy tests with practically the same size plant under identical conditions and with identical coal, taking a common heat value for average bituminous coals, 13,000 B. T. U. per pound, showed that the plant duty is less than 2 pounds per K. W. H. with gas and $5\frac{1}{2}$ pounds with steam. Furthermore, the fuel consumption of the steam plant was found to increase much more rapidly in the comparison with the poorer grades of coal. This is reasonable, owing to the greater difficulty in securing proper combustion. In this particular the producer has a decided and important advantage over the steam boiler.

Many more results might be cited which would strongly emphasize the high gross economy of the producer gas power plant; yet it is not the

* Non-condensing.



THE 800-HP. GAS-POWER RAILWAY AND LIGHTING STATION OF THE BOROUGH OF WALTHAMSTOW, LONDON

formal efficiency test at full load, but the long-period test which reveals to the operating man the fullest economy of gas working.

The results in Table II. may be of interest, as obtained from a large gas power railway and lighting plant at Walthamstow, England, which will later be mentioned in further detail. Walthamstow is one of the largest suburban districts of London, having a population of 116,000, and served by a gas-driven central station.

A striking series of comparative observations between a steam and gas station operated by the same company at Guernsey, England, has shown that with the same load factor, which is high, owing to power supply, the gas power plant consumed about 2.25 pounds per K. W. H., and the steam station 5.5 pounds, although a much larger station and equipped with triple-expansion, high-speed engines.

A producer, if provided with an automatic blast control, may be made almost instantly responsive to variations in demand for gas. This is shown by the success which the suction producer has attained in small sizes; and in this respect the steam boiler is quite outclassed, owing to the more direct effect of the blast in transferring the heat content of the coal to the working medium,—gas. In one type of producer familiar to us as possessed of this automatic feature the steam blast, and consequently the gas generated, is controlled entirely by the pressure in the delivery gas main and in inverse proportion. It combines this feature with the conservation of the sensible heat of gases leaving the producer. By this means steam is generated at a rate proportional to the demand for gas without requiring extra boiler equipment or fuel. This largely increases the producer efficiency. In some types of producer

TABLE I.

SUMMARY OF RESULTS—PRODUCER GAS TESTS

U. S. Government, St. Louis, 1904-1905

175 kw.—235 H. P. Producer Gas Plant—Belted—Full Load

Approximate Calorific Value Dry Fuel	14,000	13,000	12,000	11,000	10,000	Summary
Number of Tests	4	5	3	3	2	17
Average Length in Hours	17½	32¾	22⅓	23¾	23¾	25
FUEL.						
Name	W. Va.	Ind., Ill., Ala., Ky. Ind. Ter.	Ind., Ill., Col.	Mont., N. D., Texas.	Wyo. and Texas.	U. S.
Character	*Bit. R. M.	Bit. R. M.	Bit. and Black Lig.	Lignite.	Bit. and Lig.	Bit. and Lig.
B. T. U. per lb. Dry	14,501	13,225	12,667	11,425	10,792	12,854
B. T. U. per lb. Actual	14,223	12,303	10,942	8,242	8,458	11.346
GAS.						
Yield cu. ft. per lb. dry	66.4	51.06	50.5	31.9	32.7	49.0
B. T. U. per cu. ft	145.3	154.6	153.3	168.5	160.4	155.3
Producer Efficiency—%	65.4	64.9	70.8	65.9	62.1	65.9
PLANT DUTY.						
Lbs. per BHP Hour, Actual	1.16	1.51	1.44	2.28	2.12	1.62
Lbs. per KWH, Actual	1.82	2.38	2.27	3.59	2.83	2.50
Lbs. per KWH, dry	1.79	2.21	1.95	2.52	2.55	2.16
B. T. U. per BHP Hour., Actual	16,498	18,580	15,755	18,780	17,920	18,375
B. T. U. per KWH, Actual	28,890	29,295	24,838	29,600	23,915	28,350
B. T. U. per KWH, Dry	29,975	29,225	24,725	28,800	27,505	27,790

*Bituminous run of mine.

TABLE II.

RESULT OF 12 DAYS' OPERATION, WALTHAMSTOW, LONDON, JANUARY, 1902

Average output per day in K. W. H.	1,525
Average load in kw	64
Average load factor	35%
Coal (anthracite) per K.W.H. in pounds, including fuel for boiler and banking	1.78

THE CHARGING FLOOR OF THE WALTHAMSTOW STATION GAS-PRODUCER HOUSE

the fuel for steam amounts to as much as 15 to 20 per cent. of the total coal gasified.

This producer is designed for use without a gas holder, and has been successful in this particular. The especially severe conditions of heavy railway work, however, prescribe storage capacity at some part of the system. Owing to the limitations of gas engine capacity, electric storage is evidently the most desirable, as it relieves the machinery of the wear and tear of fluctuating loads. There is ample precedent the world over for the use of a storage battery auxiliary in railway plants, and it should prove even more desirable in a gas power than in a steam power plant. In fact, gas storage is often to be desired in many plants where the gas demand varies greatly, simply as an insurance against poor gas, due to careless operation. This, however, simply relieves the gas generating equipment, while electric storage relieves the entire station.

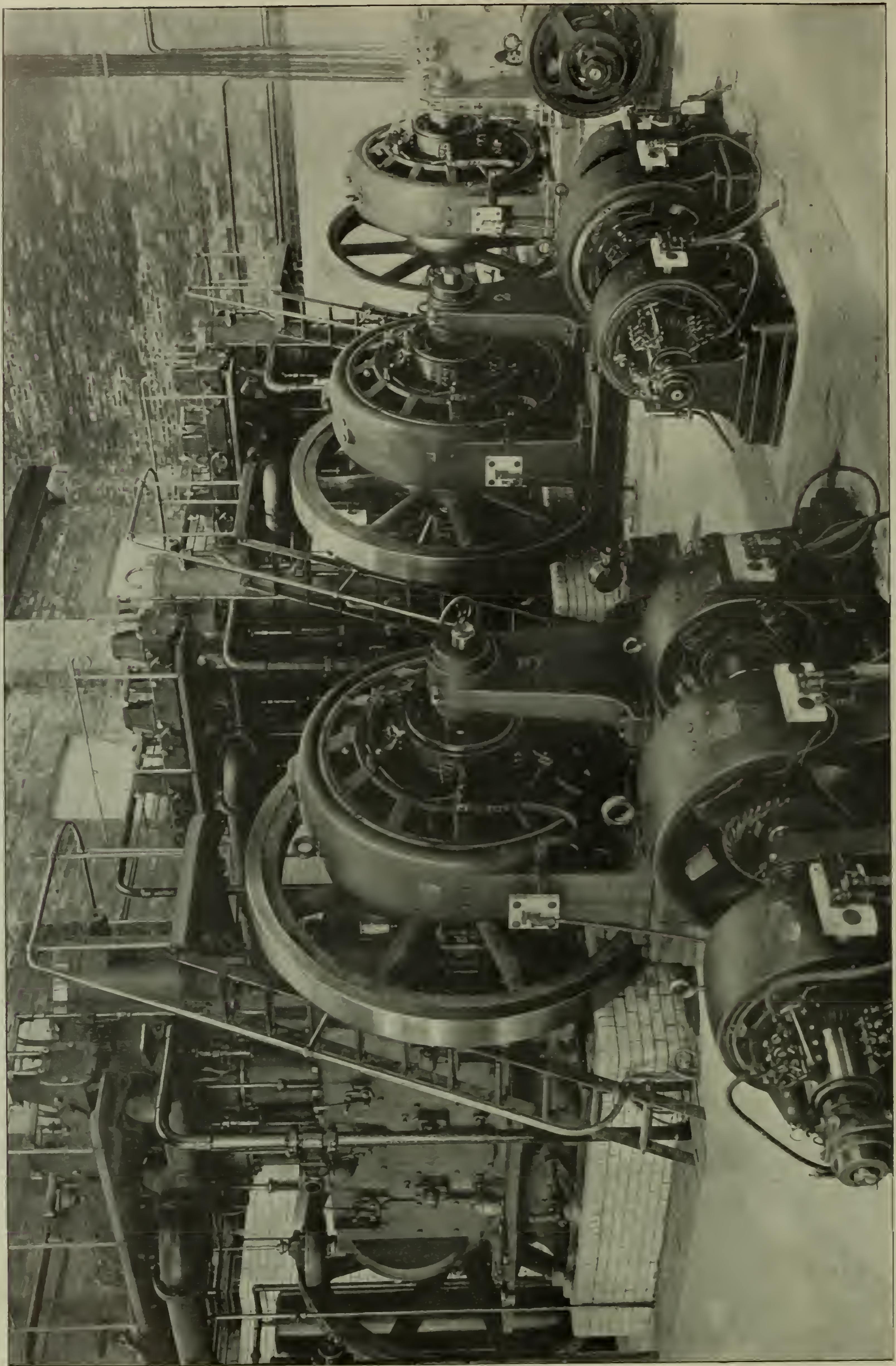
Standby losses in a steam power plant are an important source of inefficiency and difficult to determine accurately. Mr. Dowson has made some comparative observations* with eight steam plants and several producer plants, averaging about 250 H. P. capacity. The actual standby fuel consumption of the boilers was 35 to 180 pounds per hour and of the producer 2 to 4 pounds per hour. Whether the exact ratio holds for larger plants is immaterial. We do know that the producer losses are almost inconsiderable, which is reasonable, owing to the great heat content of the fuel bed and small opportunity for loss of heat by radiation when the producer is shut off from the atmosphere. Running losses are evidently also much less. We may pipe gas for great distances with small loss. Not so with highly superheated steam under high pressure. When a gas engine plant is shut down the losses practically cease; with steam, condensation is uninterrupted.

The comparative cost of labour and supplies for gas and steam plants is difficult to state in definite terms. With the same character of labour there should be no appreciable difference between the two. Figures from eleven London district stations, as compared with the gas plant at Walthamstow, show a labour cost slightly in favour of steam, but it must be remembered that this is a comparison of one gas plant, having small units, against a number of larger steam plants, which might readily be more favourable in larger gas installations. With an up-to-date steam plant, using high-pressure steam, superheaters, economizers, high-grade condensing apparatus and the like, the labour item should, if anything, exceed that of a gas plant equipment of the same grade.

It is true that a gas plant cannot be successfully operated by an ignoramus, any more than can a high-grade steam plant. A fair comparison will not admit of any but intelligent labour in either steam or gas plants, so there is no reason why steam engineers, after proper instruction, cannot take charge of a gas plant, as has been proven in practice.

A very important point, however, is the personal attitude which engineers take toward gas machinery.

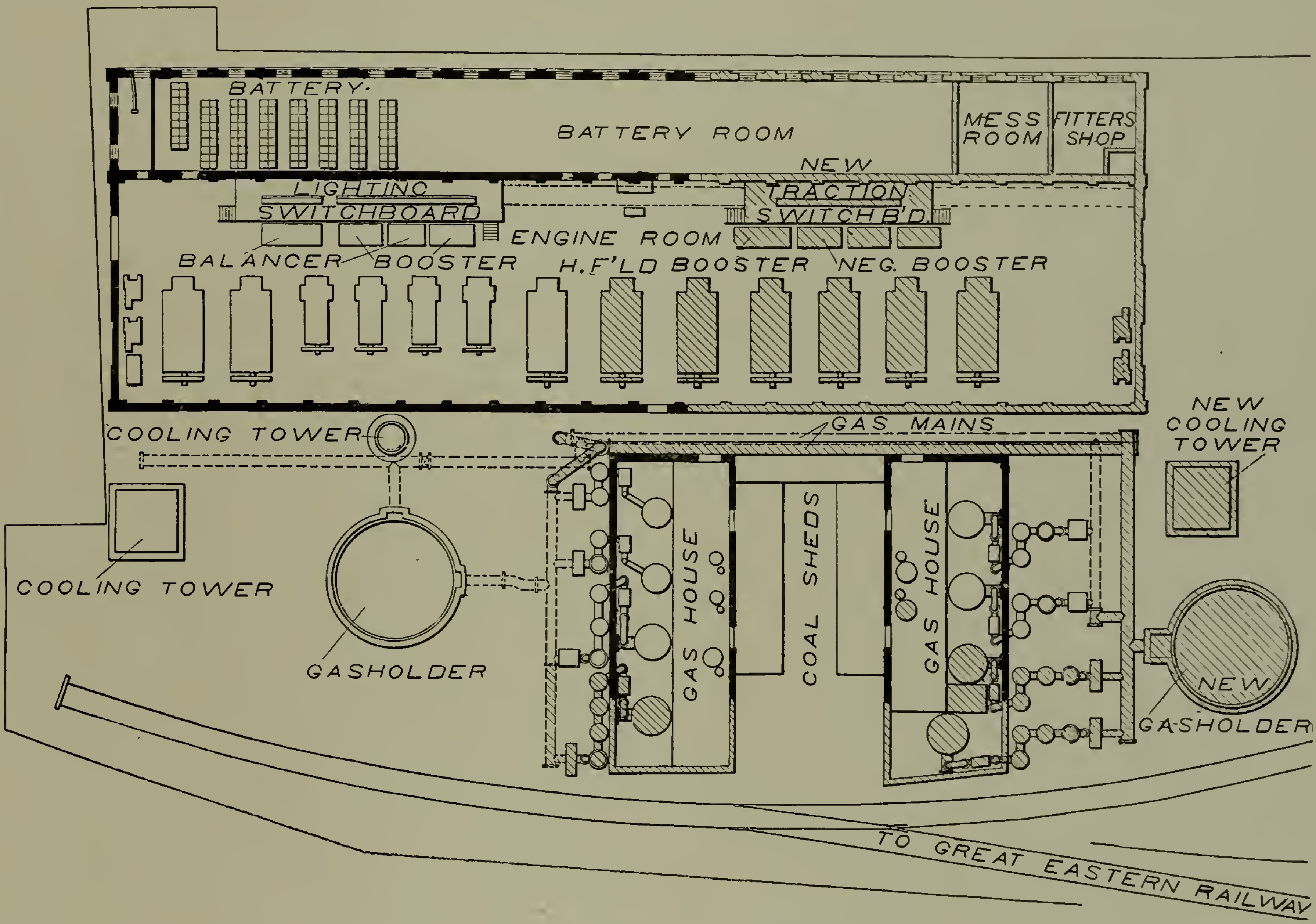
* Journal of Institution of Electrical Engineers, April, 1904.



THE MIDLAND RAILWAYS DOCK TERMINAL GAS-POWER PLANT AT HEYSHAM HARBOUR, ENGLAND

The best plant will quickly depreciate in the hands of operators who have taken a personal dislike to the innovation. The inevitable result of such attitude cannot be truthfully laid to the door of gas power. But it is almost always the case that personal prejudice may be overcome by systematic educational methods. In many of our plants the old steam engineers and oilers have been retained and placed in charge of gas equipment, after a thorough coaching by competent erecting engineers. After this is done properly the inevitable result is highly successful operation.*

In well-regulated plants, equipped with a continuous return system, the oil consumption should not much exceed, if any, that of a steam plant. Two 500 KW. gas plants at Franklin and Bradford, Pa. (each consisting of five Westinghouse vertical enclosed type engine units), average through the year less than half a gallon per unit day, at a total cost of under seven cents (0.0032 gallons per H. P. day). At another station, near Warren, Pa., using three vertical open-type engines of 275 H. P. capacity each, the oil consumption averages under 0.9 gallons per unit day. This is certainly not excessive; in fact, the writer knows of a large steam station in the Pittsburg district, equipped with several 1600 H. P. cross-compound engines, in which the oil consumption averages 0.0025 gallons per engine H. P. day, and has reached double this amount for weeks at a time. This plant has a return oiling system; the others have not.



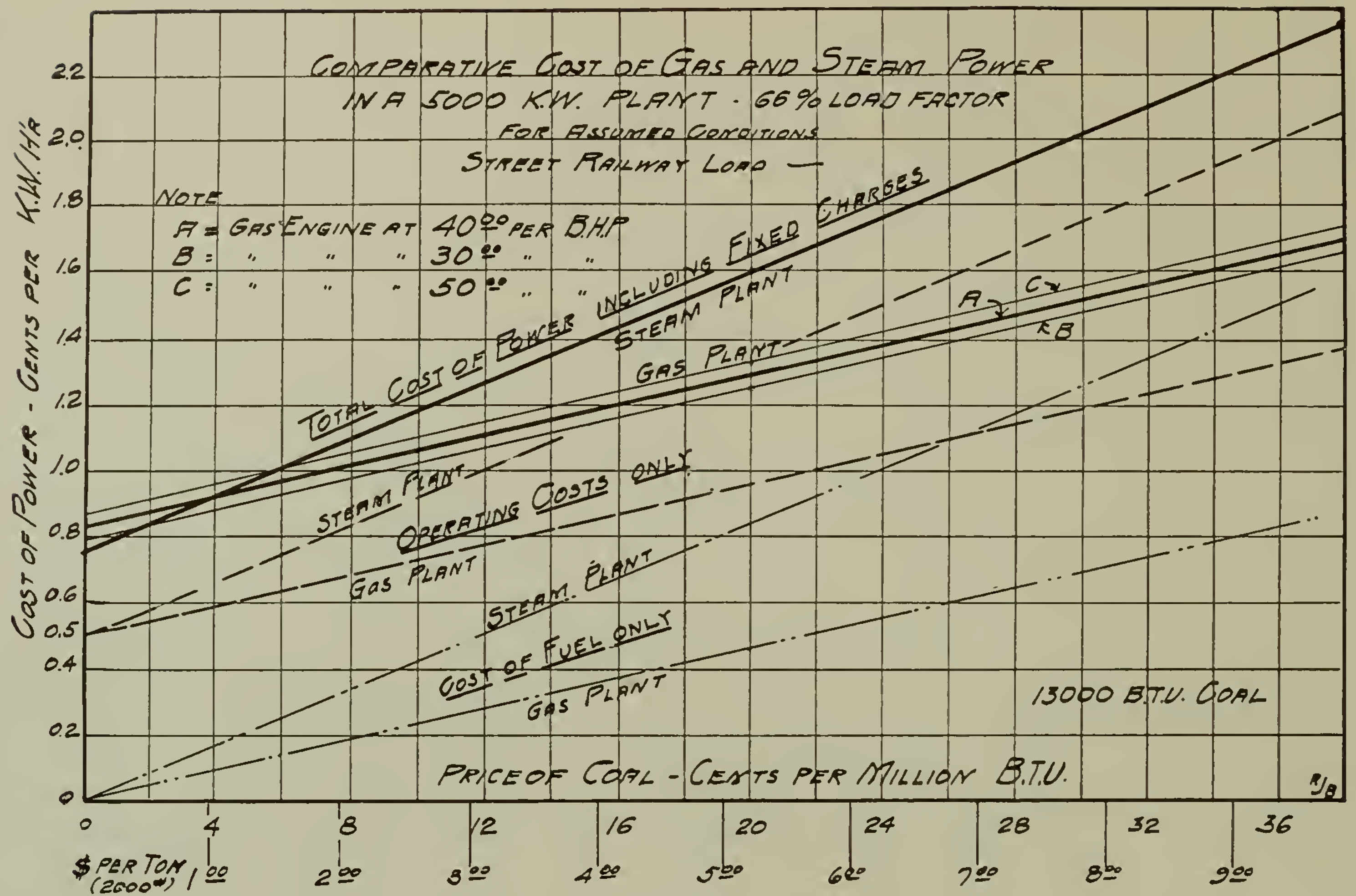
PLAN OF THE WALTHAMSTOW GAS-POWER STATION

MAINTENANCE

Maintenance expense is frequently thought to be excessive in a gas station. When this is so we may look for faulty operation or design of the plant. Recent data from the station at Bradford, Pa., show what may be accomplished when the equipment is properly operated. The plant is in its seventh year of service; yet the average cost of repairs on the engines for the last two years was $92.70 per year, 11.6 cents per H. P. year, or 0.0125 cents per K. W. H. generated. As an example of the results secured, the following may be mentioned:—After six years' service, averaging 18 hours per day, it is found necessary to inspect the engines only once in twelve months. This was formerly done in three months and later in six months. At each inspection a set of piston rings is replaced by new ones, whether worn out or not. Up to the present time no extensive repairs have been made on any of the engines, except a voluntary change, on the builders' part, from dry to water-cooled exhaust valves. The present exhaust valves average one year's working without regrinding, and even then are not in bad condition. Some valves have run 15 months. Admission valves require no attention. Igniters average about nine months without repointing. By reversing the current each day electro deposition is entirely avoided, so that the points wear evenly.

In a 300 KW. manufacturing plant at Birmingham, using Westinghouse vertical engines and Mond gas, the typical year's expense for repairs and renewals was but 0.174 cent per K. W. H. generated, incurred in the

* As the chief engineer operating a plant in Northern Pennsylvania stated to the author recently,—"I would rather throw up my job than go back to steam." He freely acknowledged his initial prejudice, which disappeared as he became acquainted with the gas engines.



RELATIVE COSTS OF STEAM AND GAS POWER FOR DIFFERENT GRADES OF COAL

proportion of 65 per cent. to the gas and 35 per cent. to the engine plant.

A notable run was recently reported by the superintendent of a gas compressing station in central Ohio, where a 650 H. P. Westinghouse vertical engine is at work.* This engine was under maximum gas load continuously night and day for 40 days, without a misfire or mishap of any kind, and without incurring extra expense for repairs.

COST OF POWER

Comparative plant economy is best brought out in figures expressing the total operating cost of power. The complete returns from Walthamstow show that with a load factor of only 15½ per cent. and coal at $6.75 per ton, delivered, the total cost of generating current was 1.7 cents per K. W. H.; or, based upon current delivered to consumer, 2.13 cents per K. W. H., the average price obtained being 7.14 cents, and the net profit 9 per cent. In the average borough steam plant of over three times the capacity and of higher load factor, the generation cost has been shown by returns to be 2.2 cents. It is presumable that the steam plants used cheaper coal; yet with gas coal at $6.75 a ton, the saving in cost of coal alone was over 38 per cent. in favour of the gas station. At this price the Walthamstow plant required throughout the year's run but slightly over two pounds of coal per K. W. H. generated. Of the total operating cost, fuel represented 43 per cent.: in the steam plant, 55 per cent.; repairs, 5 per cent. for gas, and 20 per cent. for steam. At the Birmingham plant, mentioned above, the total operating cost was 1¼ cents per K. W. H., of which fuel represented 26½ per cent. and repairs 14 per cent.; this on a load factor of 43 per cent. average, and bituminous coal having 31 per cent. volatile. The total coal consumption averaged 2.9 pounds per K. W. H. through the year.

At the Badford, Pa., station, although handicapped with old type belted machinery, the average yearly gas consumption is less than 25 cubic feet of gas per K. W. H. on a 19½ per cent. load factor, and a total operating cost of power of about 0.8 cent per K. W. H.

The station at Franklin, Pa., operating on natural gas of exceptionally high calorific value, gives experience of similar character. The engines regularly operate thirty hours to a run.

With a load factor of 15 per cent. to 20 per cent., as low as 17 cubic feet of gas per K. W. H. was recorded for the year 1904, at a total operating cost of under one per cent. per K. W. H. In the cases of both the Bradford and Franklin plants building heating by natural gas is included in the gas charge for the engines.

CAPITAL COST

Much of the prejudice against gas power is due to exaggerated statements regarding the comparative capital cost of steam and gas equipments. In some instances it has been stated that for the same character of equipment the gas plant costs double. This is not the case; in fact, in larger plants the two may be brought nearly to a parity, and the higher economy of the former will soon wipe out the difference in actual cost.

The writer cannot do better than cite the returns* of tenders for one of the largest gas power stations in Europe, over 8000 KW. in capacity, and designed for both railway and lighting service. Tenders were invited for both steam and gas equipment complete, in every respect the best obtainable and with considerable spare plant. An approximate summary of the tenders received from over thirty of the most prominent European manufacturers is as follows, including erection, but not including transportation charges.

The engineer's report on the accepted tenders shows a total excess

* After running practically day and night for nearly three and one-half years, the total repairs on the plant have been:—
One set of igniters.
Two sets of exhaust valves (one spare).
One admission valve (jammed accidentally).
One cylinder head (cracked from mud deposits).
One intermediate gear.

* For obvious reasons the names of the customer and manufacturers are withheld.

CAPITAL COST GAS AND STEAM PLANT PER KW CAPACITY.

(From Actual Tenders on European Plan.)

	Gas Plant		Generating Plant		Total
	$-Kw.	% To'l.	$-Kw.	% To'l.	$-Kw.
Average tender...	35.00	31.2	77.00	68.8	112.00
Accepted tenders.	2.400	24.5	74.00	75.5	98.00
Steam Plant					
Lowest tender....					75.00
Highest tender...					106.00
Mean tender.....					90.00
Recommended...					92.00

cost of gas plant of 7.4 per cent. actual, or 14 per cent. with certain extras charged to the gas plant for additional ground and building requirements; yet the annual saving in operation is estimated sufficient to annul the excess cost of gas plant in less than two years. Capitalized at 5 per cent. interest, this annual saving represents a capital of $1,485,000, or considerably more than the original cost of the entire gas power station. In other words, the gas plant might have cost twice the actual amount and still realize a definite saving over steam power. Incidentally, the efficiency guarantees are of interest. These are shown in Table III. The heat conversion efficiency of the generating equipment at two-thirds load is as high as 25 per cent., giving an overall plant efficiency of about 18 per cent. The average well-equipped steam plant rarely exceeds 10 per cent.

The problem of gas vs. steam power thus partakes of the nature of economics, rather than mechanics. In order to demonstrate more clearly, the diagram given on page 12 was prepared, which shows the relative cost of steam and gas power for different grades of coal. By expressing the cost* of the latter in terms of million thermal units, the differentials in transportation are avoided. This diagram is based upon an actual load curve, and the present approximate cost of power plant equipment, f. o. b. factory, but including erection.

It will be observed that the diagonals for steam and gas intersect at the left of the diagram. The interpretation of this is that at this point, with coal costing 3.5 cents per million B. T. U., or about 90 cents per ton, both plants can deliver power at the same cost, or, in other words, we cannot afford to use gas plant with cheaper coal.

Upon the assumption of equal labour, supplies, and repair costs, it is quite evident that any excess fixed charges on the gas plant will fix a definite economic limit of saving over steam, and it thus occurs that gas will be more effective where fuel is not dirt cheap. If, however, a gas plant can effect a saving in the cost of labour, supplies, and repairs, as is the case at Walthamstow, then it may be operated to advantage on still lower grades of coal.

* In estimating the cost of labour, supplies and repairs, these three items are assumed to be the same for either steam or gas plants, as it is a reasonable assumption that any possible excess cost of upkeep on the gas engine equipment would be balanced by the smaller expense of maintaining the producer equipment.

FIELD PRACTICE

This subject may be well concluded by a brief perspective, as it were, of the work that has already been accomplished in the American gas power field. To be sure, the application to railway service has in this country been limited; yet we find abroad many evidences of successful working. A prominent European engineer reported in 1903:—"Nineteen stations on tramway work, totaling 6000 H. P. capacity. These include Barcelona, Tunis, Lausanne, St. Gallen, Poictiers, Orleans and Zurich, from 400 to 600 H. P., each working on either producer or town gas." As a result of the excellent experience with the Walthamstow electricity station, 650 H. P. has been added to the plant for operating the new tramway system* recently constructed. At Buenos Ayres, South America, two plants, aggregating 2240 H. P., are at work for the Buenos Ayres, Great Western and Great Southern Railways. Both use Mond gas.

But, eclipsing in interest probably all former gas power railway undertakings is that of the Warren and Jamestown Railway system† now under construction.

* Length of line, 9½ miles, 100-pound girder rails, thirty-two double-deck, single-truck cars, double trolley.

† Following the precedent established by the Warren plant, the Union Traction Company, of Independence, Kan., has adopted double-acting engines of the same size, type and design for railway service, using Kansas natural gas as fuel. The initial equipment will comprise single crank and double-crank units of 500 and 1000 HP. each (sea level rating).

The Warren and Jamestown Railway is a high-speed interurban road, approximately 21 miles in length, operating over a comparatively level and straight right of way between Warren, Pa., and Jamestown, N. Y., at the southern end of Lake Chautauqua. The population of the territory traversed is estimated at 50,000, with 11,000 tributary, not including a large summer population at the various lake resorts. Heavy high-speed cars will be used, approximately 52 feet over all, and with a normal seating capacity of 54 persons, each car being equipped with four A. C. 50 H. P. motors on 33-inch wheels. Four cars will be operated at present.

Power will be generated at the power house now operated by the Warren Street Railway, at Stoneham, four miles south of the city. For some time gas engines of the vertical single-acting type have been used for operating the present city railway system, and it is due to the general successful experience from gas power that gas engines will be used for operating the interurban road.

A noteworthy feature of the new interurban system is that Westinghouse single-phase apparatus is used throughout, with 22,000 volts transmission and 3300 volts on the trolley, which is of the Westinghouse catenary construction. A step-up transformer station is located at the power house and two step-down sub-stations are about one mile distant from both Warren and Jamestown. These equipments contain transforming, switching and protective apparatus alone. As no direct current is used upon the system, it is impracticable to employ storage batteries, so that the generating equipment will thus be required to sustain at all times the entire demand. In the present city system a 150-ampere hour (one hour rating) storage battery is in use, which is kept floating on the line throughout the load fluctuations, to the relief of the gas engine equipment. In the new plant the gas engines must sustain both load and fluctuations without assistance. Each unit complete of the new equipment occupies a floor space of 20 x 47½ feet, allowing 4 to 5-foot passageways, which is equivalent to 3.65 square feet per KW., or 1.9 square feet per H. P. capacity.

This plant will practically inaugurate the use of the heavy-duty type engine, in connection with single-phase railway systems in America.

The new engine equipment consists of two 500 H. P. Westinghouse double-acting engines of the horizontal

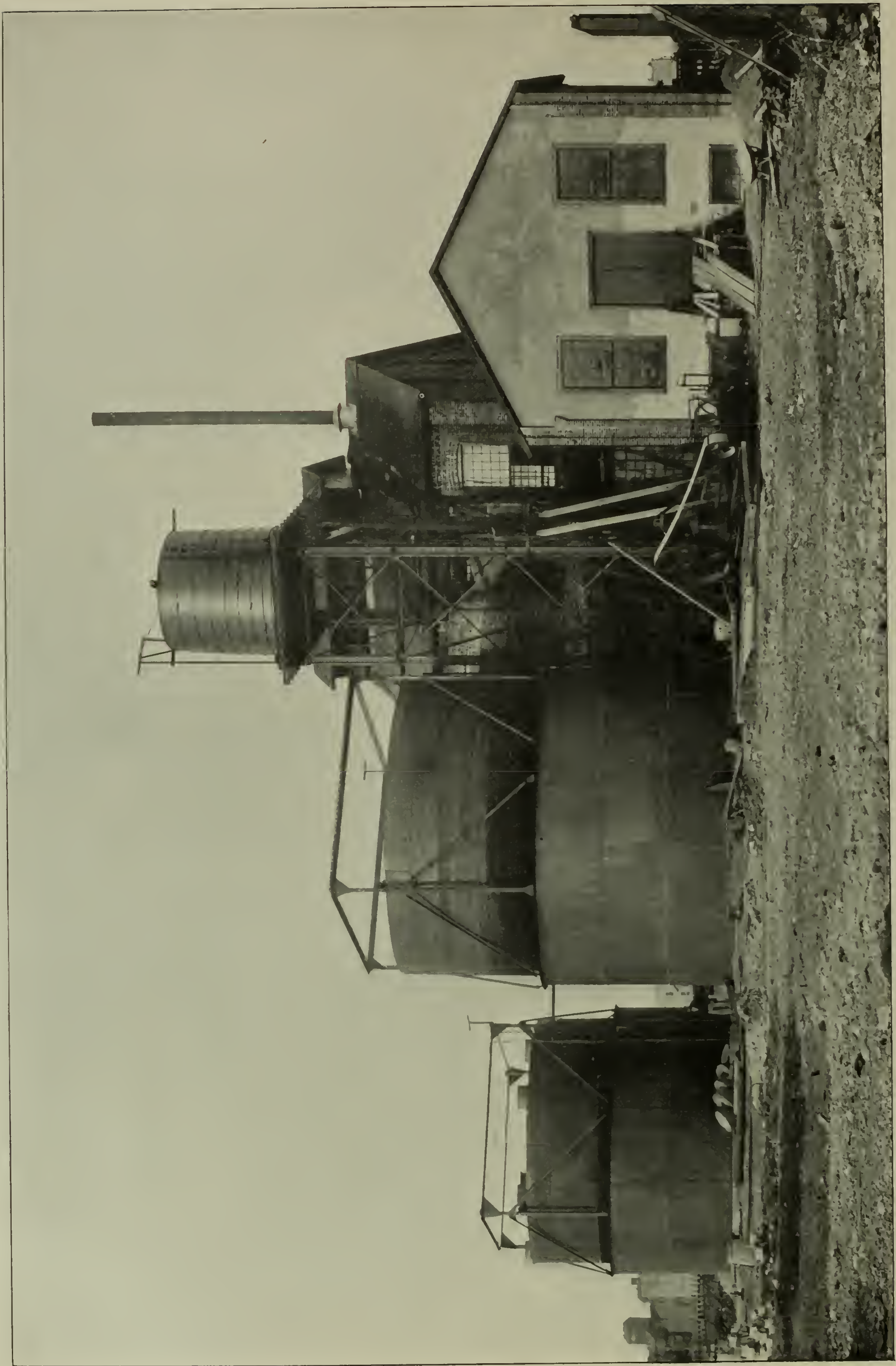
TABLE III.—SUMMARY OF GUARANTEES

(From Actual Tenders on European Plan.)

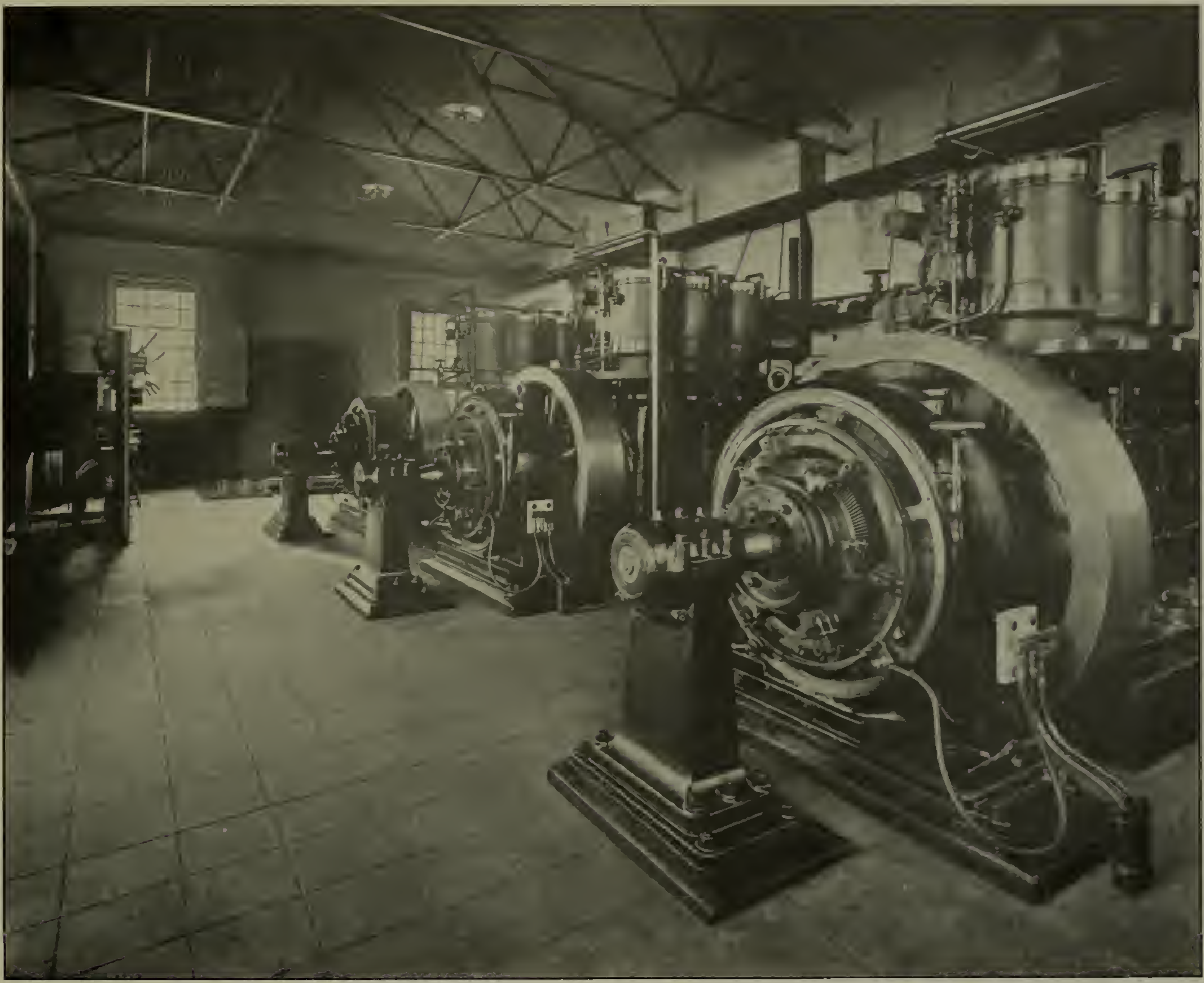
Guarantee.	Producer Plant: B.T.U. in Gas Per Lb. Coal.	Producer Plant: Efficiency with 12,000 BTU Coal. %	Generating Plant, 2-3 Rated Load: B.T.U. per K.W.H.	Generating Plant, 2-3 Rated Load: B.T.U. per B.H.P. Hr.	Generating Plant: †Kinetic Efficiency %	Power Station: Kinetic Eff. with 12,000 BTU Coal. %	Power Station: Plant Duty Lb.* Coal per K.W.H.
Highest	9,500	79.2	12.300	10,440	27.7	21.9	1.29
Lowest	7,000	58.3	18,000	15.290	19.0	11.1	2.57
Average	8,729	72.7	13,876	11.775	24.6	17.85	1.59
Accepted	8,500	71.0	13.700	11,630	24.9	18.1	1.61

*Computed from Producer and Engine guarantees.

$$\dagger\text{Kinetic Efficiency} = \frac{\text{Heat equivalent of work done}}{\text{Heat input}}$$



THE GAS-POWER INSTALLATION OF THE ATHA TOOL COMPANY, NEWARK, N. J. A TYPICAL PLANT FOR COMBINED POWER AND METALLURGICAL SERVICE



IN THE ENGINE AND GENERATOR HOUSE OF THE ATHA TOOL COMPANY

tandem type,* each direct connected to a 260 KW. A. C. engine-type generator. These engines are both of the single-crank type, but with the tandem arrangement, a power stroke is developed at each half revolution, as in the double-acting steam engine. The gas units will operate in parallel on the electrical end without the necessity of synchronizing the cranks.† Owing to the absence of battery and the small number of cars, the plant will be subjected to the most severe test possible. It is estimated that one generating unit will take care of the present maximum demand with two cars starting and two running.

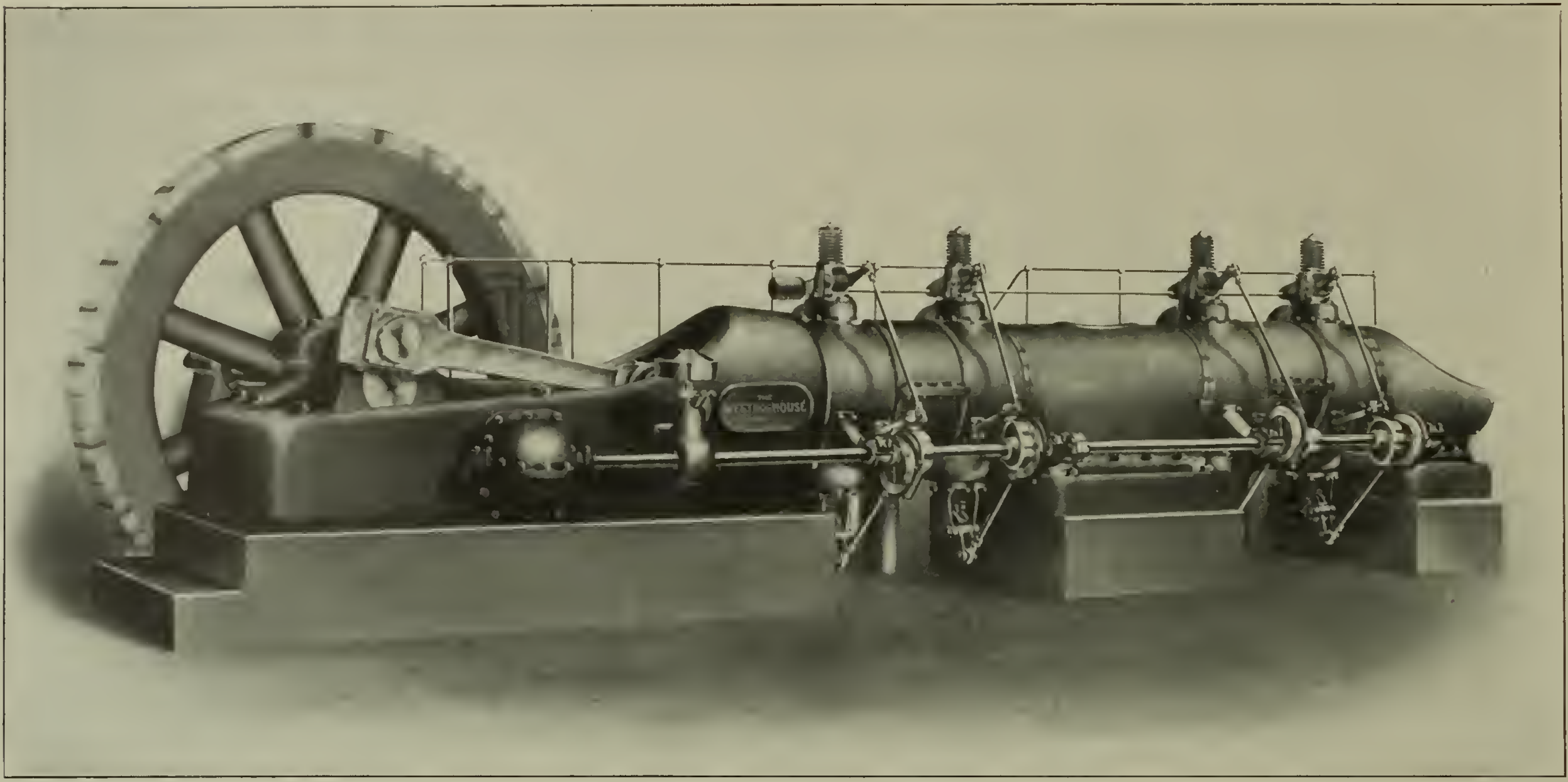
Natural gas fuel is entirely used in this territory, and at the present price and heat value will correspond with producer gas delivered at a cost of about two cents per thousand cubic feet. The economy in operating with natural gas is striking. In the old gas plant it is estimated that the cost of power averages 0.75 cent per K. W. H., including all items chargeable to operation, except repairs on building and battery, the corresponding gas consumption being 20 cubic feet per K. W. H.

Among gas power stations in American and British territory we find a large number up to 2600 H. P. capacity operating on producer, natural and oil gas, and many with the A. C. system with generators running in electrical parallel. In fact, parallel operation by gas engines on a large scale was first accomplished in this country at East Pittsburg, with three-cylinder engines of the vertical single-acting type. In view of the success with this type of engine, it is evident that the tandem and twin-tandem double-acting type should be even more suitable. In Great Britain 20 central stations, from 40 to 2000 KW. in capacity, are in operation, mostly with producer gas.

In the field of electric lighting much has been accomplished. Outside of the Walthamstow station, already mentioned, an interesting plant is the 1150 H. P. station of the Rockland Electric Company, at Hillburn, N. Y., equipped with Westinghouse horizontal double-acting engines, operating on Loomis-Pettibone producer gas. As in several other industrial plants using this type of producer, most of the water gas generated is used for furnace heating, while the "air" or "blow" gas, too lean for other purposes, is used entirely in the engine plant. In many respects this system is unique, in that it makes possible the commercial use of otherwise expensive water gas, while the cheap "air" gas is useful for generating power.

*Dimensions of engines:—Cylinder diameter, 21 inches; stroke, 30 inches; speed, 150 revolutions per minute.

† The cyclical speed variation and the governor regulation are sufficient to meet present A. C. generation specifications.



A WESTINGHOUSE HEAVY-DUTY, DOUBLE-ACTING GAS ENGINE FOR GENERATOR DRIVING

The utilization of waste products of manufacture has within recent years made great progress. Gaseous by-products have already been put to use on a large scale, but the near future may readily witness the use of the producer in its present or in modified form for utilizing all combustible wastes recoverable in manufacturing process. Blast furnace gas applications are now more or less familiar; coke oven gas from by-product coke ovens has many notable applications in Europe (a small plant is in use at Camden, N. J.); and oil gas (obtained by fractional distillation of petroleum,—a by-product in the refining process) has lately been successfully applied in America.

SUMMARY

The large number of small plants that has come within our range of experience has not prevented us from obtaining similar experience from larger ones. The operation of close to 100 plants, from 200 to 2600 H. P. in capacity, would seem to indicate that some measure of success has been attained. That one-half of the aggregate capacity operates on natural gas and but one-third on producer gas simply emphasizes the value of this country's natural resources, rather than reflects upon the producer gas system, especially when one considers the comparatively short time that producer gas has been seriously taken up. About 10 per cent. of the larger plants (above 200 H. P.) operate city and suburban railway systems. The remainder are devoted to many classes of service, such as light and power for city and suburban territory, power for the electrical driving of industrial works, power for operating railroad terminals, gas compressing stations, water pumping plants and high-service fire systems. A notable example of the latter is the 2200 H. P. station in Race street, Philadelphia. Most of the prominent types of producers are represented, including the Mond, Loomis-Pettibone, Dowson, Taylor and the more recent Westinghouse system. A few small plants are working on suction gas. This indicates that successful operation is not confined to any particular type of producer.

In conclusion, the writer can but reiterate,—

1st. That the gas engine has been brought to a state of development where it is capable of doing the same work as the steam engine, with far greater efficiency, and usually at reduced cost.

2d. That the producer has been so far perfected as to be a reliable and more efficient generator than the steam boiler.

3d. That the gas power plant "in toto" is entirely suitable for even the severe service incident to electric railway operation.

4th. That its component parts, engine and producer, are possessed of characteristics leading to harmonious co-operation.

5th. That practical difficulties incident to gas power working have been so far overcome as to warrant commercial confidence.

6th. That experience with gas power in almost every known line of modern industry has proven its general sufficiency for any power service.

Such data as have been obtainable are presented in the light of a record of past performance rather than in the nature of prophecies regarding the future. The future is believed to be already assured.

New York Electrical Society Lectures

THE New York Electrical Society has announced the following series of lectures to be given early in 1906:—

"Electrical Reactions of Gases," Peter Cooper Hewitt.

"Wireless Telegraphy," William Marconi.

"Electrification of the Long Island Railroad," O. S. Lyford, Jr.

"Newspapers and the Telegraph Art," Melville E. Stone.

"The Turbine," C. G. Curtis.

"The Place of the Electric Vehicle in Automobilism," Robert McAllister Lloyd.

"Single-Phase Railway Work," Charles F. Scott.

The recent completion of an electric road between Findlay and Lima, Ohio, now makes it possible to travel a distance of 615 miles by electric lines from Titusville, Pa., to Crawfordsville, Ind.

Electric Power Transmission in Northern California

The Plant of the North Mountain Power Company

THE DITCH THROUGH WHICH THE WATER IS DIVERTED TO THE PLANT OF THE NORTH MOUNTAIN POWER COMPANY

AMONG the power transmission systems of the Pacific Coast, that have been constructed with an eye to the future, rather than the present, needs of the communities which they serve, one of the most interesting is that of the North Mountain Power Company. This plant is located in the central part of Trinity County, California, two miles below the town of Junction City, where Canon Creek, from which the water used for power is obtained, flows into the Trinity River.

Weaverville, the county seat, is twelve miles distant by road. The nearest railroad point is Redding, on the "Shasta Route" of the Southern Pacific Railroad; Humboldt Bay, on the Pacific Ocean, with Eureka, the chief coast city of Northern California, lies almost due west, distant 59 miles in a straight line.

The altitude of the plant is about 1400 feet. All material, cement and machinery were hauled in over 60 miles of the severest mountain roads, across three distinct divides or summits. It required 18 to 20 animals to pull each of the larger pieces, weighing 18,000 pounds, up the grades, and when mud was encountered it was necessary to hitch 18 animals to the fall of a block and tackle fitted with steel cables. Despite these difficulties, however, no mishap occurred to any of the machinery.

The water used at the plant is diverted from Canon Creek, which has a drainage area of 52 square miles above the diverting dam. The upper part of the basin is a rugged, glaciated granite country, extending up to an altitude of from 9000 to 10,000 feet above the sea level, where some snow remains throughout the year. The higher parts of this basin are in the nature of an immense amphitheater, lying on a flank of Thompson Peak, which is a characteristic feature of all elevated glaciated topography. And, as is so often the case, the converging and descending glaciers have scooped out immense holes with almost perpendicular sides, which now form the beds of two lakes. These have been utilized as storage reservoirs. Part of the watershed is heavily timbered, and lies within the boundaries of a government forest reserve. This will insure the preservation of the forests, which are so effective in steadying the run-off.

The average annual rainfall for the last thirty-three years at Weaverville, twelve miles from the plant, has been $42\frac{1}{2}$ inches. At the higher levels of the watershed the precipitation is much greater, but no records are available for that region because the country is absolutely uninhabited and even without trails, except for the one to the above-mentioned lakes.

The dam is small, and serves merely for diverting the water. It is of the usual rock-filled crib form which has been the type used for many years in mining operations on the Pacific Coast. The ditch system consists of alternating sections of ditch and flumes, with one tunnel. Part of the ditch is cut in solid rock, but the most of it is dug in the side-hill soil, which stands well. The flumes are 19 in number and vary in length from 30 to 1200 feet. Those immediately below the dam are laid upon a solid bed-rock bench, and equipped with adequate spill-ways, waste gates and sand-boxes. The total length of the flumes is 5250 feet.

A tunnel 1821 feet long has been driven to replace a temporary flume which was unavoidably built upon treacherous sliding ground. This tunnel is heavily timbered throughout its entire length, and tightly lagged except where the rock is unusually hard. The dimensions of the main tunnel are 4 feet 9 inches by 5 feet 10 inches in the clear. The total length of the ditch, flumes and tunnel is $7\frac{1}{4}$ miles. The average grade of all is 0.00184 or 9.73 feet per mile. The ditch is provided with waste-gates and sand-boxes at suitable locations. The capacity of the ditch is 80 cubic feet per second, which is sufficient to operate at full load three units like the two which are now installed.

Near its lower end the ditch passes through a gap in the narrow ridge separating Canon Creek from Trinity River and terminates in a forebay on the river side of the divide. Thus is secured a head due not only to the fall in Canon Creek in the seven miles through which the creek and ditch parallel each other, but also to the additional fall in a further course of two miles to the creek's junction with the Trinity River, and to the added fall in two miles of the river's course between the junction and the plant.

A telephone line extends from the power house along the entire course of the ditch to the head dam. Instruments are placed in the station, the forebay tender's cabin, the head gate-tender's house, and at several other points along the line. Portable telephones can be readily connected at any point, and, as a result, any place along the ditch can have prompt communication with the power house.

The forebay is excavated out of the solid rock of the hillside, 10 feet deep, 14 feet wide and 60 feet long. The ditch is provided with a gate at its entrance to the forebay, and the latter contains a gate and grizzly, or grating, at the intake of each of the two penstocks. Provision has been made for a third penstock when a third unit shall become necessary in the

GENERAL VIEW OF THE TRINITY RIVER PLANT OF THE NORTH MOUNTAIN POWER COMPANY IN TRINITY COUNTY, CALIFORNIA. WATER IS DIVERTED FROM CANON CREEK, AND IS CONVEYED THROUGH 7¼ MILES OF DITCH, FLUME AND TUNNEL TO THE POWER HOUSE

plant. Suitable trash-racks are provided just above the forebay.

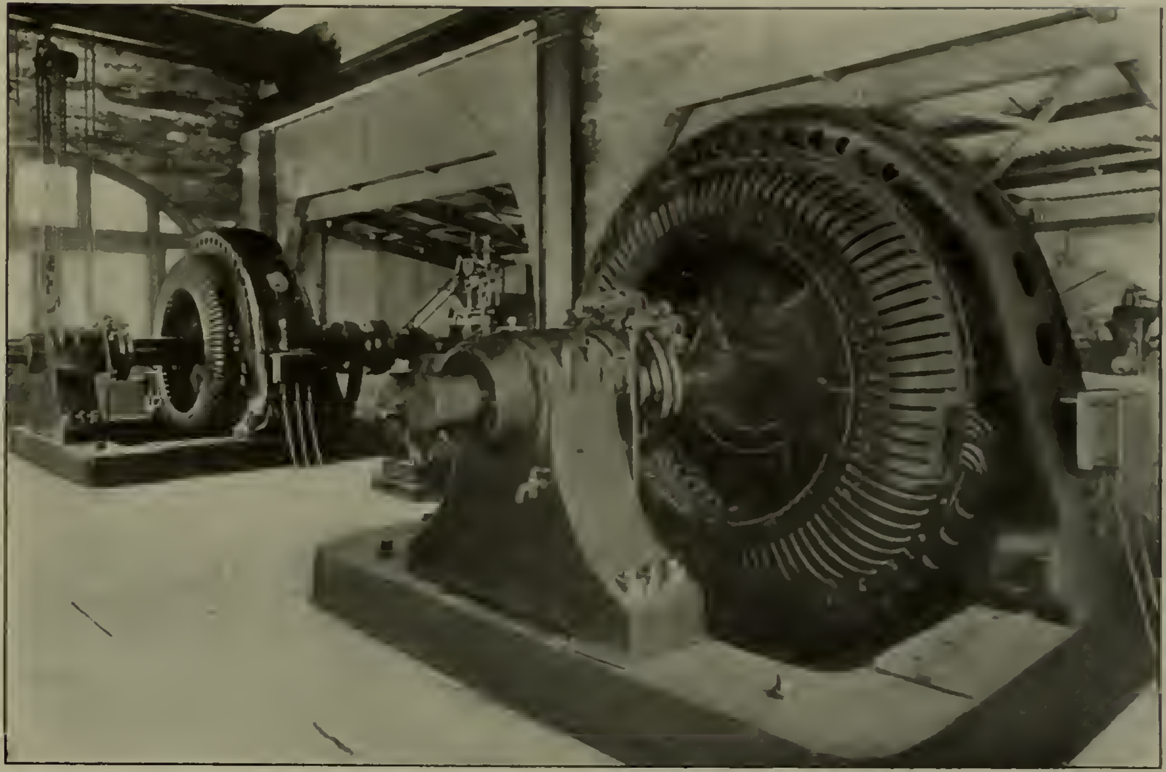
The penstocks, two in number, are each 1165 feet long. Under a total head of 604 feet there is an effective head of 600 feet, or working pressure of 260 pounds per square inch. There is one complete independent penstock for each of the two units. Each consists of a line of 36-inch and 28-inch pipe, and at the lower end two lines of 18-inch pipe, all of riveted steel of various gauges, according to the position in the line. At the Y's, or points where the single 28-inch pipe branches into two 18-inch lines, the penstocks are enclosed and anchored in a massive block of masonry laid up with imported Portland cement mortar. At their lower ends, just before entering the power house, they are secured by a similar form of construction, and at various points they are held by bands and anchor bolts leaded and sulphured into the bedrock. Throughout their entire length they are laid in trenches and covered by back-filling, except at their lower ends, where the profile of the hill is such that it was best to lay each in a separate tunnel. After completing and testing the penstocks, the tunnels were walled up and back-filled.

The penstocks are each provided with an 18-inch stand-pipe just outside the forebay walls, to allow air to enter when the forebay gates are closed, and thus prevent collapse of the pipe. They are also provided with air valves and man-holes at suitable points.

The buildings of the plant proper include the power house, the transformer house and the high-tension switch house. In addition there are the shop, the operator's dwelling and the stable. At the forebay is the forebay tender's cabin, and at the dam is a house for the tender of the head gates.

Each of the two hydraulic units consists of a pair of 44-inch Pelton wheels under one sheet-steel housing, coupled to a generator through flexible leather link couplings. The wheels are controlled by Lombard governors using oil. The pressure and vacuum are maintained by oil pumps belt-driven from the wheel shafts. The governors are not fitted with any form of switch-board speed control, but a single operator has no difficulty in synchronizing a generator under the load conditions existing in the plant. The tail race is 6½ feet wide and is excavated for 280 feet through bedrock to Trinity River.

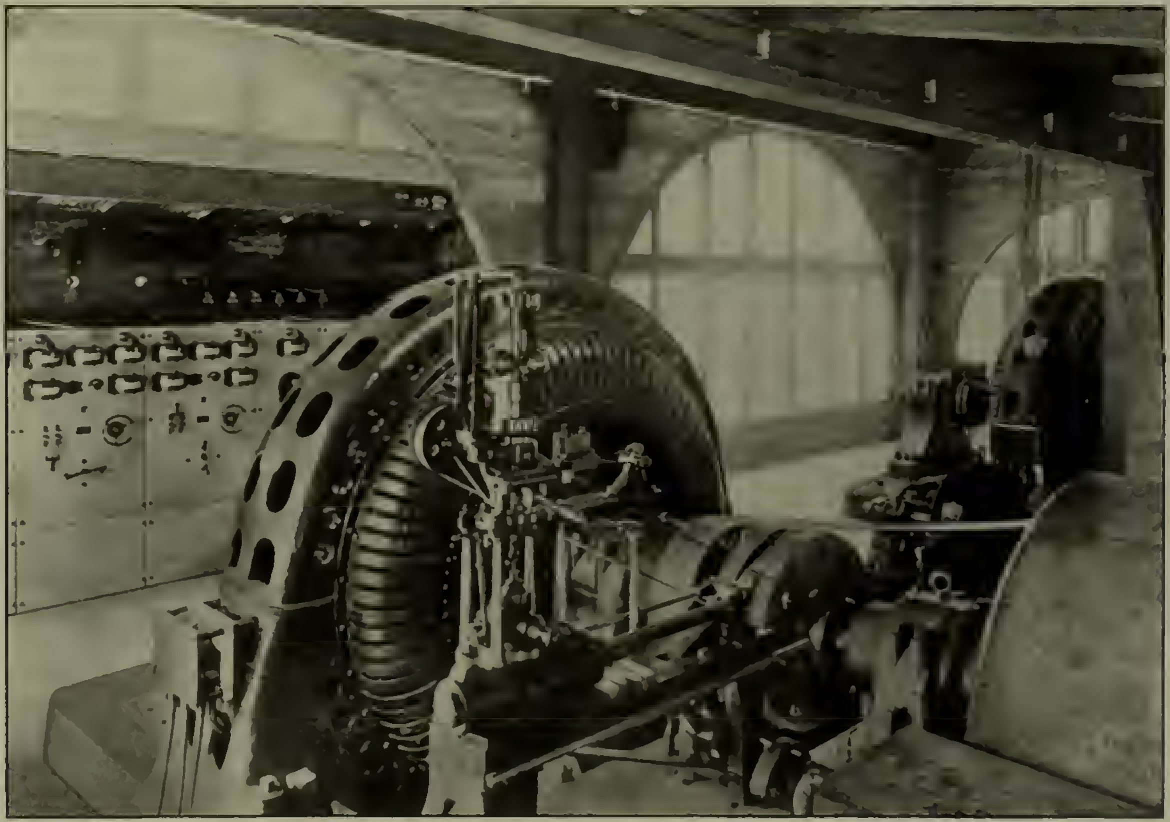
The generators, two in number, are of the Bullock six-pole, revolving-field type furnished by the Allis-Chalmers Company, of Milwaukee, Wis. They run at 500 revolutions per minute and supply three-phase, 25-cycle current at 2200 volts. Each is of 750-KW. capacity. Two 45-KW- Bullock exciters are driven by belts from the generator shafts at 900 revolutions per minute, supplying current at 125 volts. The switch-boards are of marble and are provided with Wagner instruments.



TWO 750-KW. BULLOCK THREE-PHASE ALTERNATORS, BUILT BY THE ALLIS-CHALMERS COMPANY, OF MILWAUKEE, WIS., GENERATE 25-CYCLE CURRENT AT 2200 VOLTS

The power house, 36 by 51 feet, is built of concrete, made up with sand and gravel. A special bay or alcove has been provided to give ample space behind the switch-board. The roof is of corrugated iron supported on steel trusses. A hand-operated crane spans the main part of the building. This easily handles the heaviest piece of machinery. The leads between the generators, exciters and switch-board are lead-covered cables laid in conduits within the concrete and cement floor.

The transformer house is 13 feet by 51 feet 6 inches, and is also built of concrete. It is 50 feet distant from the power house, and contains seven step-up transformers, two banks of three each and one in reserve. They are of Bullock make, 300-KW., water-cooled, oil-insulated, 2200-19,050



EACH UNIT IS PROVIDED WITH A LOMBARD WATER-WHEEL GOVERNOR FOR REGULATING THE SPEED OF THE PELTON WHEELS

ALL THE MATERIAL AND MACHINERY FOR THE POWER HOUSE WAS HAULED OVER 60 MILES OF ROUGH ROAD, A 20-HORSE TEAM BEING NECESSARY TO HAUL THE HEAVIER PIECES

volts, 25 cycle. Each bank is located in a separate room, and the seventh or spare transformer is in a third room. They stand upon rollers which in turn rest upon tee rails set into concrete piers. The spaces between the piers are filled with gravel and provided with sub-drainage so as to allow any oil to rapidly escape in case of leakage or accident.

The water piping is connected up with unions and so arranged that every transformer is interchangeable with every other one, as far as water and electric connections are concerned. A track runs the entire length of the building, and at such an elevation that the floor of a car is at the same height as the rails which are imbedded in the concrete piers. Thus any transformer can be quickly rolled out upon the car, removed, and another reconnected in its place in case of accident.

The penstocks are each tapped in the power house, and after passing through shut-off and throttling valves under the control of the operator, water is delivered into a cylindrical steel tank, 36 inches in diameter by 24 inches long. This storage tank is set upon a little knoll about 20 feet above the level of the transformers. From this tank the water circulates through the cooling coils of the transformers by gravity. The transformers are connected in delta on the low voltage side, and in Y on the high voltage side, with ungrounded neutral, giving a potential on the line at present of 30,000 volts.

The high-tension switch house is 16 feet by 36 feet, a frame structure covered with corrugated iron, and 20 feet distant from the transformer house. In it are two banks of single-throw, air-brake switches, and General Electric alternating-current multiplex lightning arresters, connected up for the three-phase circuit.

The pole line extends almost due west from the plant to the sub-station in Eureka. The length is 65 miles. Of this, 55 miles are over a severely rugged, mountainous country; the altitude of the plant is only 1480 feet, and Eureka is at a sea level, but the line passes over several summits ranging from 4500 to 5500 feet in altitude. Fifty miles of its length lie in a heavily timbered country, requiring a tremendous amount of clearing, the trees ranging from 2 feet to 4 feet in diameter. It was necessary to construct a trail nearly the entire length of the line.

The route deviates from a straight line only slightly and only where the topography made it unavoidable. It is a "through" transmission, so to speak, there being no taps on the line

THE 300-KW. BULLOCK TRANSFORMERS ARE OF THE OIL-FILLED, WATER-COOLED TYPE, STEPPING UP FROM 2200 TO 19,050 VOLTS. THEY ARE CONNECTED IN DELTA ON THE LOW-VOLTAGE SIDE, AND IN Y ON THE HIGH-VOLTAGE SIDE, GIVING A LINE POTENTIAL OF 30,000 VOLTS

anywhere between the plant and the sub-station at Eureka. The line is a single circuit, three-phase, averaging 35 poles to the mile. The poles are redwood at the western end; in the inaccessible stretches the native red fir was the only wood available.

The insulators are Locke two-piece, single-petticoat, porcelain, 8½ inches in diameter, made by the Locke Insulator Mfg. Co., of Victor, N. Y. The pins are sun-dried eucalyptus, oiled, and 1½ inches in diameter.

The spread of wires on the standard length spans is 40 inches. The wire is No. 4 copper, except on some long spans, where stranded cable is used. The length of span varies from 50 to 1400 feet according to the conditions and topography of the country.

The telephone circuit is No. 10, B. B. galvanized wire, carried on glass insulators. Telephones are connected to the line at several of the cabins which have been built for the accommodation of the patrolmen, and at frequent intervals are "pole-boxes," consisting of magneto-generator and batteries into which the patrolmen plug their pocket sets and thus have long-distance, loud-talking instruments.

The sub-station at Eureka includes an auxiliary steam plant as follows:—

Two Babcock & Wilcox water tube boilers fitted with Peabody oil-burning furnaces and duplicate oil-pumping system; Goubert auxiliary feed water heater; Wheeler surface condenser with self-contained steam-driven air and circulating pumps, cooling water being taken from Humboldt Bay; and a McIntosh & Seymour tandem-compound engine of 700 indicated horse-power, nominal rating. A jackshaft running at 500 revolutions per minute is connected to the engine by rope-drive.

A six-pole, 500-KW. Bullock rotary converter, running at 500 revolutions per minute and supplying 25-cycle current at 550 volts, is arranged for direct connection to this jackshaft by a jaw clutch, and so driven by the engine. This permits of carrying the load by steam when necessary to shut down the transmission line for repairs.

The engine is fitted with a switchboard speed-control device. The clutch has a synchronism indicator in the nature of a lamp, so that the engine may be connected to the rotary while it is running at full speed on the power transmitted from the Trinity River plant.

For the rotary converter there are three Bullock transformers of 190-KW. capacity, water-cooled, 25-cycle, with a ratio of 30,000-352 volts. For stepping down for the local distributing system are three General Electric water-cooled transformers of 400-KW. capacity.

For furnishing power to the 60-cycle incandescent and arc-lighting circuits of the city of Eureka, a three-phase, 60-cycle generator is driven by the rotary acting as a synchronous motor.

The sub-station is fitted with switchboards and high-tension switches suitable for handling this equipment. A fuel oil tank 54 feet in diameter by 25 feet deep, holding 10,000 barrels, has been built near the sub-station, and is connected to a dock on Humboldt Bay by a pipe-line.

The sub-station is 31 feet by 128 feet, built in the marsh on the waterfront of Eureka. Heavy concrete foundations rest on redwood piles cut off below low-tide level.

The load at present consists chiefly of lights in the city of Eureka. Some motors are already connected to the circuits, and the motor load is being rapidly developed. Local transmission lines are being constructed about the shores of Humboldt Bay and in a very short time the company will be supplying power to the local companies in Eureka's suburbs, not only for light, but for motors in the various industries of that rapidly developing region.

A British Single-Phase Railway

THE London, Brighton & South Coast Railway Company have decided to electrify their South London line on the single phase, high-tension system between Victoria and London Bridge. The contract for the complete equipment of this line has now been placed with the Allgemeine Elektricitats Gesellschaft, of Berlin. In the event of negotiations now pending between the Brighton Railway and the contractors being completed, the only materials supplied from Germany will be the motor equipments for the first few trains, which will be included in the proposed contract. All remaining materials, including trucks, car bodies, and overhead equipment, will be supplied by British manufacturers and carried out by British sub-contractors; and any further orders for motor equipment, if placed with the Allgemeine Elektricitats Gessellschaft, will be manufactured in Great Britain.

A new development in electrical welding is the automatic production of continuous rolls of wire fencing, says "The Iron Age." A number of galvanized wires are fed from reels arranged vertically and parallel to each other, and from another reel placed transversely to these are cut off lengths of wire, which are fed horizontally across the vertical wires. Where the horizontal and vertical wires intersect, these are welded together. The welded section then moves forward a predetermined distance, and the operation is repeated.

Electricity in the Astronomical Observatory

By H. S. KNOWLTON

TO the average engineer, the commercial applications of electricity are so vast and varied that there is little time or opportunity to ascertain the progress which of late years has been made in the adaptation of electrical methods to the field of scientific research. He knows that investigators are pushing their experiments forward in industrial, educational and governmental laboratories, supported by the accumulated scientific experience of perhaps the most remarkable century known to history, but there is seldom a chance to pause long enough among the responsibilities of modern life to appreciate the part which electricity is playing to-day in the realms of pure science.

A case in point is the use of electricity in the astronomical observatory. Perhaps no one but an astronomer can realize the innumerable advantages and possibilities in the way of improved conditions of observation which the employment of electricity guarantees to-day. While it doubtless would be untrue to state that without electrical appliances modern astronomical research would be tremenduously handicapped, there is no question that the convenience, comfort and accuracy of such work are vastly facilitated by the use of the incandescent lamp, the electro-magnet, and the small motor.

In working with very large telescopes it is often with serious difficulty that the observer follows the movement of the eye-piece. The Yerkes telescope, at Lake Geneva, Wis., U. S. A., for example, is 62 feet long, with a 40-inch aperture, its eye-piece being 30 feet higher when observing near the horizon than when observing near the zenith.

The use of ladders and adjustable chairs was impracticable, so the problem was solved by equipping the floor with a motor drive capable of raising it 22 feet vertically. A similar arrangement was provided for the Lick Observatory, at Los Angeles, in California, and the increase in safety and comfort insured by this method is notable.

Another important use of electric motors is found in the operation of observatory domes, and in large instruments small motors are employed for giving the proper motions in ascension and declination to the telescope itself. In connection with the larger instruments, such as the Lick telescope, the Yerkes telescope and the 36-inch telescope in the Naval Observatory at Washington, D. C., motors are used for automatically winding the driving clocks, the switches being so arranged that when a clock is nearly run down the motor is cut in circuit and then switched out again when the clock is wound.

At the Harvard Observatory in Cambridge, Mass., the new 24-inch telescope recently mounted is to be operated entirely by electricity, for which purpose a synchronized electric motor will be substituted for the older method of driving by clockwork that so long has been used in propelling equatorials.

In some observatories, trouble has been experienced by the condensation of moisture on various parts of the equipment, and there would seem to be no reason why the judicious use of fan motors might not relieve the situation in much the same way that shop windows are kept clear of frost in the winter season. Certainly, the fan motor deserves a place in every laboratory and work room where concentrated metal tasks are performed under trying weather conditions, and it is no exaggeration to state that the under part of an observatory dome on a warm summer's night generally offers an attractive field for this kind of an installation. The application of the electric motor to large telescopes means facility and economy of time, decreased cost of operation, and lessened intricacy of mounting; it also marks a positive advance in the mechanism of scientific research.

The use of the incandescent lamp in connection with equatorial telescopes, meridian circles, transits, etc., is an important feature of the engineering side of astronomy. The principal point to secure is the illumination of the spider-lines or cross-wires in the focus of the instrument.

In determining time by means of the meridian circle, the observer inclines the telescope at such an angle that the star is seen to traverse the field of vision between two horizontal threads; he then records the exact times, by means of a push button circuit, chronograph, and sidereal clock, at which the star appears to cross each of the equidistant vertical threads, the average of these times representing the time of transit across the meridional axis of the instrument.

Since these observations are made at night, the field of view is dark and the exceedingly delicate spider-lines would be invisible unless artificially illuminated. The small incandescent lamp, with suitable reflecting mirrors, lends itself admirably to this purpose, and if the lamp is supplied with current from a storage battery the conditions become almost perfect, in the way of steadiness of illumination. The absence of dirt, gas, and odours is also worth emphasizing. A point of interest is the ease with which the degree of illumination may be varied by the use of small rheostats placed upon the instruments.

The graduations on micrometer heads, the markings on the position circles of the micrometers used on equatorial telescopes, and the scales of large circles in the best modern practice, are also lighted by electricity.

It has been found a great convenience to light with electricity the observatories themselves, from the fact that the current can be turned on and off so easily. In some cases the interior of the observatory is provided with a very slight illumination all the time, this being just enough to enable the astronomer to safely move about without hitting the instruments. Verniers and micrometer microscopes are also good subjects for the electric light.

The storage battery occupies an important place in the equipment of the modern observatory. Steadiness of current is a prime requisite in accurate operations, and for running electro-magnetic releases in connection with work in celestial photography the storage battery is exceedingly reliable and useful. In photographing a star, for example, it is necessary that the telescope shall exactly follow the apparent movement of the heavenly body throughout the time of exposure, whether that be accomplished in one or three nights.

Telescopes used for this work give better results when driven mechanically, and so complete is the modern equipment for this purpose that it is only necessary for the apparatus to be set, started, and then left to itself for the photograph to be taken, the astronomer stopping the mechanism at any predetermined time.

The impulses for releasing the driving clock-work are given accurately by a clock pendulum through the medium of a relay. The clock pendulum is fitted with a small horseshoe magnet at its lower end, which swings back and forth over a small armature held down by a horizontal spring from actually touching the magnet itself. At each stroke of the pendulum the armature is raised, perhaps 0.03 inch or enough to close the relay contact, which in turn sends the storage battery current through the releasing mechanism on the telescope.

In addition to their use in chronograph circuits, telegraph sounders are employed for comparing clock rates. The sending of hourly electric time signals is an interesting feature of the Naval Observatory's work at Washington, D. C., and the time signals sent forth from Greenwich, England, are of equal interest.

The development which has been attained in astronomical instruments during the past few years illustrates wonderful progress beyond the methods and equipment of half a century ago, and in the advance of the future there is no doubt that the usefulness of electricity will be still further increased.

Montana's Copper Output in 1904

In his annual report on the mineral production of Montana during 1904, B. H. Tatem, United States Assayer, says that the mining of copper continues to be the noteworthy feature of the mining industry in Montana. More than 64 per cent. of the total values won from Montana's mines in 1904 consisted of the gold, silver and copper contained in the ores mined at Butte. The effect of this mining of copper ores at that place is enormous and far reaching. Although the cities of Butte, Anaconda and Great Falls in Montana owe their maintenance largely to the mines at Butte, it is because of the copper furnished to the markets and industries of the world by the Butte mines that the price for copper has been greatly cheapened. This has in turn lessened the cost of electrical installations for power, while industrial enterprises generally have been undertaken in all parts of the country more energetically and more profitably. Almost one-fourth of the world's entire output of copper in 1904 came from Butte—283,945,330 pounds, valued at $36,410,309.67.

New York City's Coal Consumption

The coal tonnage of the largest American city has always been a topic of interest to the trade, says "The Coal Trade Journal." It has never been an easy matter to ascertain the tonnage used, as precise data are unavailable. Prior to the expansion of the city limits it used to be said that 6,000,000 tons would cover requirements; then after Brooklyn, Queens and Richmond were added on the tonnage was estimated at 12,000,000 tons. With the co-operation of important interests we have prepared a revised statement by which it will be seen that a very notable increase in tonnage has developed within the past few years. The totals, 9,000,000 tons of anthracite and 6,500,000 tons of bituminous, making a grand total of 15,500,000 tons, are substantially verified by various railroad reports, and we have endeavored to distribute this tonnage among the several classes of trade according to advices received from well informed shippers and dealers. The result for 1905 follows:

ANTHRACITE

	Tons
1. Domestic, private houses and small stores using mostly egg, stove and nut	2,500,000
2. Flats and apartment houses, heating, etc., using mostly broken or pea and buckwheat	3,000,000
3. Hotels, clubs, theaters, factories, institutions, etc.	1,500,000
4. Gas requirements, estimated from annual reports	900,000
5. Elevated and surface railroads, about one-third of their total tonnage	400,000
6. Steamboats, tugs and shipping, also steam railroad fuel, for heating, etc., within city limits	400,000
7. Department stores, office buildings, etc.	600,000
Total	9,000,000

BITUMINOUS

	Tons
1. Steam trade, factories, refineries, etc., including gas and electric plants	3,000,000
2. Steamship bunkering	3,000,000
3. Heating stores, office buildings, etc.	400,000
4. Blacksmith trade, including wheelwrights and carriage manufacturers	75,000
5. Fuel for stationary plants, construction work, etc., of steam railroads within the city	25,000
Total	6 500,000
Grand total	15,500,000

Notes.—There is a small amount of coke and charcoal used in New York for special purposes, but this business is to be calculated in pounds, rather than in tons.

Locomotive tonnage is, in the main, excluded. The Long Island Railroad is the only road having its principal coaling station within the city limits, and some of that tonnage may be in under the steam trade headings of each subdivision. From points on their lines the New York Central and New Haven Railroad Companies send into the Grand Central Station or other city terminals such coal as may be required for outgoing trains. Railroad coal for stationary plants, heating, etc., is delivered in carloads or by stevedores, according to whether or not carting is required.

The manufactures of New York exceed in value those of any other American city, but the amount of coal used in connection therewith, aside from three or four refineries and the making of gas and electricity, is not as great as may be supposed from the value of the output. Leading lines are clothing, books and periodicals, and candy, none of which requires much power. Pianos, paints and varnish and cordage are also important lines of manufacture which require very little fuel.

Electricity from Garbage in Switzerland

According to United States Consul-General Guenther, at Frankfort, Germany, a garbage incinerator was recently erected at Zurich, Switzerland, steam being generated to furnish electric power.

The plant contains twelve furnaces capable of burning 120 metric tons (1 metric ton = 2204.6 pounds) of garbage in 24 hours. The wagons loaded with garbage are lifted by means of an electric derrick upon a platform above the furnace, into which the garbage is dumped.

As garbage, however, does not burn easily, an electrically driven blower injects a strong current of air which has been heated by passing through flues in the furnace walls. The heat engendered by the burning of the garbage is sufficient to make steam in two large boilers of 120 pounds pressure. The electric power produced is used first for the purpose of the plant and to supply part of the power for the electric railroads of the city. Complete combustion of the garbage does not take place. From 30 to 40 per cent. of its original weight remains in the form of slag. This slag, by mixing with lime, is used for making bricks and paving blocks. The plant is said to be paying well.

The principal centers of the calcium-carbide industry in France are in the Alps and Pyrenees. At present, according to a writer in the "Journal" of the Society of Arts, there are eleven manufactories capable of turning out 40,000 tons of calcium carbide annually. The total output sold during 1904 may be estimated at 18,000 tons. The average yield of gas per unit of weight of carbide is about 40 gallons per pound. A new form of oxyacetylene burner has been devised in France, by means of which a very intense light is produced by allowing the jet to impinge upon a suitable mixture of the rare earths.

Municipal Lighting Plants

By A. S. HATCH

IN describing the engineering, investment and operation of municipal plants of different sizes, ranging from those in the smallest villages to the largest ones, one meets with the difficulty that the smaller plants keep incomplete records. The purpose of this article will, therefore, have to be modified. at least with regard to the operating cash costs, which can be gotten only by an examination of the city books.

The smallest plant examined by the writer is in a village about one-half mile wide and one mile long, with a population of 1100. The only protection against fire is a hand engine and the wells of the village. The streets are lighted by 24 arc lamps, and there are about 150 incandescent lamps burning on commercial circuits. The plant is located in a gristmill, and is operated under contract at a minimum cost of $90 a month. The plant consists of a 240-volt, direct-current generator of 50-KW. capacity, and a 35-ampere storage battery and switchboard. The distributing system consists of two feeders, one for commercial and the other for street lighting. There are 24 constant-potential, enclosed-arc lamps supported on 14-foot mast arms, the current supply being over a No. 14-gauge iron wire.

The special feature of this plant is that the water works are an adjunct of the lighting plant instead of the reverse. On the bank of a small stream is built a large cistern, and in a shed close by is placed a motor-driven pump which is connected to a 3-inch pipe system extending through the main streets of the village, for the purpose of supplying hydrants in case of fire. With the storage battery, power is always available in the case of fire. The cost of this plant was, for the electric lighting, $7000, and for the fire pump, $2000. The cash cost of operation is about $1200 a year, of which the commercial lighting pays about $500, but the village is taxed for $1000, the balance constituting a sinking fund. In another village of similar size, using a direct-current plant, but no storage battery, and run in connection with the water works, two collector rings were put on the generator and alternating current taken off for the purpose of supplying light about two miles away.

Two classes of municipal plants are in operation in the United States, one doing commercial lighting as well as street, and the other doing street lighting only. All the small plants belong to the first class, and nearly all the municipal plants of large cities belong to the second class. Of 35 plants with which the writer has been connected, 28 are of the first, and 7 of the second class, and of the 28, only 4 have direct-current systems, the rest using alternating, and that in some cities where the central point of distribution is within 1000 feet of the station.

A comparison of investment costs of two plants of the same size, one with direct and the other with alternating current, shows a very marked increase in the cost of the latter system. This is due to the use of small direct-current arc machines for street lighting and a large number of small transformers on the alternating system.

With the exception of the one plant noted, these are all located in the water-works buildings, and in many cases the engineering has been done by attaches of the contracting firms; consequently, the costs are exceptionally high, and a description of one is that of all. The building contains two 100-H. P. boilers, a feed-pump, and a water-works pump set to keep a constant pressure of 40 pounds on the mains, or a tank for the same purpose. The electric plant consists of one engine, belted to a direct-current arc dynamo for street lighting and an alternating-current dynamo for commercial lighting, and a switchboard with voltmeters, ammeters, a main switch for the alternating current and plug jacks for the arc circuit. Only one arc and one alternating circuit are taken out. The street lamps are hung in the center of the street by means of span wires, very few mast arms being used. A transformer for nearly every customer is installed, and but few meters are used, the rates being mostly flat. In an inspection of one city it was found that the necessary improvements could not be done on account of there being no funds available because the bills were not paid.

One of the smallest plants of the second class is located in a city of about 25,000 inhabitants, and consists of three 175-H. P. boilers and two 400-H. P. engines, direct connected to the same shaft. Belted from this shaft are five dynamos, each having a capacity of 80 direct-current arc lamps. A total of 330 lamps are on five circuits strung in ribbon shape, that is, the positive leads of all five go out in the same direction, and, circling around the city, return to the plant together, from the opposite direction. The investment cost of the plant was about $60,000, and the last year's operating cash cost was an average of $45.48 a lamp.

The growth of this plant illustrates the methods adopted by the average municipality in the purchase of machinery. The first installation consisted of two boilers, one engine and three 100-light, open-arc dynamos and about 200 lamps. The first addition consisted of two 80-light dynamos and a number of enclosed-arc lamps. This represented a total investment of about $45,000. The latest addition consisted of a boiler, engine and three dynamos, with 200 enclosed-arc lamps, but two dynamos and 159 lamps were discarded, giving an actual increase of only 41 lamps, and an additional investment of $20,000. There was a difference of over $4000 between the highest and lowest bids, yet the highest bid was accepted. Two bids on the same make of boiler, but with different engines, were over $2000 apart, yet the higher bid was accepted.

The largest city engaged in municipal lighting is Chicago, but although over 5000 lamps are in operation, they are supplied by four plants; consequently, the largest plants are those at Columbus, Ohio, and Detroit, Mich. These are of the second class, that is, they do no commercial lighting. Columbus is a city of about 17 square miles in area, and has a population of 125,000. The plant supplies street lamps only, no incandescent lamps being used, such service being purchased from the local company. The plant is located on the water-works grounds, 1½ miles from the center of the city, and consists of four 300-H. P. water-

tube boilers, three 400-KW. steam turbines with feed pumps, condensers, fuel economizers, etc. Between the boiler and engine rooms is a steel stack 175 feet high and 9 feet in diameter.

Part way across the side of the engine room, opposite the boiler room wall, is the switchboard gallery, under which are one transformer and a regulator for each circuit, each switchboard panel having two circuits. The switchboard consists of 23 panels, one for the two exciters, three for the 400-KW. generators, sixteen for arc circuits and three selector panels which divide the circuits into three groups. By the use of oil selector switches, each group can be handled under any condition of circuits. Two auxiliary buses are provided for the purpose of connecting any circuit to an extra transformer in case of failure of the regular one. All plugging is done with stab switches instead of the usual cord and plug arrangement. One selector panel contains the indicating and integrating instruments for the total load, and another contains the testing apparatus. During the day, the circuits are tested with a battery and voltmeter, which gives the resistance between circuit and ground.

In order to test when running, a 7500-volt transformer is used. The secondary of the transformer is wound for different ratios to the primary, a 50 ratio giving a primary reading between 1500 and 7500 volts, a 15 ratio giving 450 to 2250 volts primary, a 5 ratio giving 150 to 750 volts, and a ratio of 2 giving 60 to 300 volts. With a condenser across the primary terminals, very little disturbance is made on the circuit when plugging the transformer between line and ground, and when once plugged on, it does not require changing in case the ground should be near one end, since the different ratios permit the voltage being read on the most open part of the scale of the voltmeter. Provision is made to allow checking the circuit ammeters by plugging in a portable meter at any time. The board was built with plugging cord for the purpose of plugging the circuits to ground during the day, but this is not advisable with alternating circuits, since the inductance of circuit and regulator is so high that a cross with commercial alternating-current wires anywhere through a greater part of the circuit would prevent the grounding of the live circuit, so that it does not remove this danger, which is the object of grounding in the station.

The distributing system is carried on two lines of poles, each one feeding a section of the city, but no tie lines across the city are provided to allow one section being fed from the other in case of fire or storm rendering a trunk line inoperative. The lines contain nearly 7000 poles from 35 to 65 feet long, and carrying about 125 miles of wire. There are a few ten-pin arms on the poles as they leave the station, but the larger number are six-pin on the trunk lines. The circuits are built for 75 lamps each, but are not run quite to the limit, which, though it makes a lower factor, allows an increase of lamps without cutting over loops or stringing additional wire on the poles already up. To prevent induction, both lead and return wires are run together in nearly all cases.

The first suggestion by the writer was to have all wires distinguished by some mark easily recognized, and this has been carried out partially, but even then more thoroughly than in Detroit. The Board of Public Service in Columbus paint the poles a dark green for about 7 feet from the ground, the remainder being white, while for a further distinction the arms and insulators are slightly different from those of the Railway & Light Company. The advantage of the system is seen when it is remembered that there are nine lines of poles in the streets and alleys of Columbus. There is no underground system from the municipal plant at present, but the lines are so laid out that in the center of the city they can be conveniently changed to an underground system in the future. The lamps are hung on mast arms, but instead of being arranged for lowering for trimming and testing, they are trimmed from a wagon having an elevated platform.

The estimated costs were, for investment \$414,585.39, made up of buildings and real estate, \$108,135.-50; steam plant, \$43,678.60; electric plant, \$77,695.92; poles and lines, \$112,142.37; mast arms and lamps, \$72,933. The operating costs as estimated would be as follows:—

TABLE I.

Executive, supervision and office	\$5,000.00
Station operating costs	19,050.00
Lighting, trimming and patrol	8,107.50
Maintenance	6,220.00
Total cash cost	\$38,377.50
Fixed costs, insurance, lost taxes, interest, depreciation	45,604.39
	\$83,981.89
Total cost per lamp	\$41.99

The Columbus plant differs from the Detroit plant in that it supplies street lamps only, while the Detroit plant furnishes a constant-potential service for city buildings. This requires extra operating expense, since the service is continuous, but not to such an extent that all the expenses between shutting down and starting up of the street lamps should be charged to incandescent service, so, before describing Detroit's plant, it may be well to notice one or two of the largest municipal plants furnishing a commercial service.

In a city of about 23,000 inhabitants, the electric light and waterworks plants are separate, the former consisting of two buildings, one about 75 by 100 feet, containing the engine, dynamos, and the superintendent's office, the other the boiler room, by the side of which is a brick chimney 125 feet high and 5 feet in diameter. Four boilers are installed, two of 100 H. P. each and two of 150 H. P. each, with heater, feed pumps, injectors, and condensers. The engine room contains one 375 and one 125-H. P., tandem-compound engines belted to a jack shaft. From this shaft are belted seven direct-current arc and 3 alternating-current dynamos, and three exciters. Between the engines is a 200-KW. steam turbine.

The switchboard is placed along the wall back of the engines and is in two sections, the arc on one side and the incandescent on the other side of the passage way into the boiler room. The arc board is a common 8-circuit board with meters and lightning arresters placed above, and at one side is an alternating-current, series-circuit panel, controlling one circuit only. The incandescent switchboard contains six panels, four generator and two feeder. All switches are of the air-break type, and the instruments are voltmeters, ammeters, and integrating wattmeters only. The distributing system is carried on two lines of poles from the station, about 1200 poles being owned by the city and 700 rented. The fire-alarm wires are also strung on the same poles with the lighting wires, which will produce induction troubles from the alternating-current, arc-lighting circuits. There are 350 series-arc and 17 series-incandescent lamps in use, supported by mast-arms or center suspensions when necessary.

The investment is not itemized, but is given as a total only—\$104,-187.04—consequently, municipal investments cannot be separated without an investigation of the city books. The operating costs have been kept during only the past five years of the twelve that the plant has been in operation, so that they can be separated into municipal and commercial expense. A tabulated account of the operation of this plant for the past two years is as follows:—

TABLE II.

	1903.	1904.
Kilowatt hours, Commercial...	$746,632.00	$893,312.00
Municipal....	457,856.00	460,134.00
Total..................	$1,204,488.00	$1,353,446.00
Cash operating cost, Labor....	$10,581.66	$10,777.08
Operating..	10,521.35	10,475.68
Maintenance.	1,791.75	1,375.08
Total......................	$22,894.76	$22,627.77
Street lighting expenses, Labor.	$3,600.00	$3,660.00
Stores	1,593.88	1,559.52
Total....................	$5,193.88	5,219.52
Cost proportional to KW. output........................	$17,700.88	$17,408.25
Cost for commercial lighting...	10,974.55	11,489.45
Cost for municipal lighting.....	11,920.21	11,138.32
Municipal cost per lamp.......	34.35	31.82
Commercial receipts....	14,210.57	15,957.85

In another city of about 10,000 inhabitants, the water works and electric light plant are located in the same building. In addition to the commercial and street-lighting service, current is used to pump water at an auxiliary station. Both plants have a boiler capacity of 400 H. P., while the electric plant has three alternating-current units aggregating 550 KW. Only 81 street lamps are in use. Of the total investment of $247,246.82, the electric light plant is charged with $105,110.55. The total kilowatt-hours output for the past year was 668,960, 34 per cent. of which was for the street lights and the pump. The total operating expense was $19,105.22; allowing certain amounts for street lighting and commercial service, which are chargeable to them only, and dividing the remainder proportionately, gives the cash cost for commercial service $12,595.70, and the municipal service $6,509.52. Allowing the operating expense for the pump at the average rate per kilowatt-hour, the balance makes the cost per street lamp $29.97 per year.

There is no municipal plant keeping a complete record, so that the different investment and operating costs cannot be determined accurately. This is true even of Detroit, where the records are the most complete. If the municipal and commercial, or arc and incandescent, investments are separated, the amounts are assumed in case the article is used in both departments, which is not necessary if a basis is first established for the right division of such costs. The operating expenses are still further assumed since there are items divided according to the output. A municipal plant is built for municipal lighting only, consequently the fixed costs should be established by such service as is necessary to supply the street lighting; to this can be added the fixed costs required for municipal incandescent service, and finally those required for a commercial service. The running expenses could then be divided on the same basis. For this reason, to the description of the Detroit plant is added a comparison of operating expenses by years, not as a criticism of the plant, but to show the defects in the system of records and how to remedy them.

In 1893, when the Public Lighting Commission was formed, 1277 arc lamps were used in street lighting, and about 1500 incandescent lamps in the city buildings in the center of Detroit. It was decided to increase the number of street lamps to 1500, and to install machinery for 1800 arc lamps and 150 KW. in alternating-current machinery for incandescent lighting. The plant as designed was to have an ultimate capacity of 4000 arc lamps, and 450 KW. in alternating apparatus. As built, it consisted of seven boilers, rated at 300 H. P. each, five 340 H. P. and one 165-H. P. engines, eighteen 100-light arc dynamos, three 55-KW., alternating-current machines, and 1600 open-arc lamps. Each of the five triple-expansion engines was belted by rope-drive to four of the arc dynamos, although it was intended at first to use direct-connected, multi-circuit machines, giving room for double the capacity.

The buildings consist of a boiler and engine buildings, between them being the stack, wash rooms, engineer's office, pump and oil rooms. In the boiler house there is floor space for three more boilers of the same capacity, and in the engine house for one 340-H. P. engine, belted to four 100-light, arc dynamos, making six units of 400-lamp capacity each, which would be replaced with twelve direct-connected units as the increase demanded. However, instead of adhering to this plan, the first increase in machinery consisted of three 100-H. P. engines direct connected to 125-light dynamos, and two compound engines belted to two of the 55-KW. dynamos and two 100-light arc dynamos, giving a capacity of 2375 arc lamps and 165 KW. in incandescent lighting, the third 55-KW. unit being in the pump room and driven by a compound engine. This filled all available space in the engine house except that under the switchboard gallery which was across one end of the building.

The number of lamps burning on July 1, 1901, was 2025, leaving only 350 in reserve, that is, the three direct-connected units; consequently, all the machinery was in use every night, and in order to increase the capacity of the plant without shutting down, the space under the gallery had to be used either for a temporary unit while one of the 340-H. P. units was being changed to direct connection and another unit installed where the dynamos are, or such machinery installed as would give the necessary increased capacity. Four systems were considered: 1, twenty-eight direct-connected units of 125-arc-lamp capacity each, and five 225-KW. alternators; 2, three engines belted to jack shafts from which the twenty dynamos then in use would be belted, together with sixteen 150-light dynamos; 3, an alternating-current system, installing five 225-KW. units connected directly to the five engines now in use, and in addition two 1700-KW. units; 4, five 225 KW., one 750 KW., and one 1700-KW. alternators, all direct connected, and after rewinding the arc dynamos for enclosed lamps, run them with synchronous motors and using direct-current, enclosed lamps for the center of the city, and establishing substations with alternating-current lamps for the outside sections. This was the recommendation of the electrical superintendent, although the superintendent would not consider anything but the second method until the cost and a sketch of the plant were shown.

As originally installed, the machinery required 3 square feet of floor space per arc lamp supplied; the second installation required but $1\frac{1}{2}$, and the last system recommended only 1 square foot. This was one of the reasons for adopting alternating current, as the buildings standing on made ground, any extension would mean a heavy expense for piling. In an estimate made at the time on a basis of 1200-arc-lamp capacity increase, the building alone would cost $15 a lamp in addition to the cost as contemplated in any of the methods mentioned. Another reason, on account of the plant being located in that section where the wires are required to be underground, was that one cable used as a feeder to a substation could take the place of several arc circuits. Dynamo and engine investment for the first system was $42.91 a lamp; for the second it was $46.10, and for the last, including transformers, $34.80.

This last system is the fourth method recommended, except that it was decided to use alternating lamps entirely. There have been added two 800-H. P., triple-expansion engines direct connected to 600-KW., 2400-volt, two-phase, alternating-current generators, and one 175-KW. machine, bought as a motor and synchronous converter, but used as a generator, rope-driven from one of the 340-H. P. engines. The three 55-KW. alternators and six 100-light arc dynamos were discarded. In

order to install the first 600-KW. unit, the gallery and switchboard for the incandescent system was removed, and a temporary board built on the main floor.

For a switchboard and transformer house, an alley between the engine house and office building was enclosed as a part of the former. The transformer room extends across the end of the engine house and is 10 feet wide and 14 feet high, made of iron and cement, its ceiling being the floor of the switchboard gallery. This ceiling is carried 5 feet farther out than the wall, thus making the switchboard gallery 15 by 45 feet. The arc distributing board is in the transformer room wall under the gallery, and consists of eight panels, six of which are each equipped with twelve pairs of spring jacks for cords and plugs, the other two panels holding the testing apparatus. The main board contains ten marble panels, each 46 by 100 inches, comprising one exciter, three generator, two incandescent, one arc and three sub-station panels. There are two sets of both primary and exciter buses, each primary being two-phase, four-wire. There are two four-pole, single-throw oil switches to each generator panel, one for each bus, so that in ordinary running the buses are in multiple, both switches being thrown. The distributing panels are equipped with double-pole, double-throw, oil switches so that the load can be put on either bus. Instead of regulating for constant potential on the busses, the incandescent system is controlled by auto-transformers, since it would be impossible to control the voltage closely with field rheostats on such large machines running in multiple.

The city was divided into four sections, one in the center controlled from the main station and three outside controlled from sub-stations. Each single-phase feeder to a sub-station was designed to carry four 65-light arc circuits in multiple, the proper voltage being given at the main station by means of step-up transformers. Should it be necessary to isolate a circuit, a one-to-one transformer is provided at each sub-station for the purpose. Each sub-station is designed for a total capacity of 1000 lamps supplied by four feeders. The switchboard at the sub-stations allows any circuit to be plugged on either of two feeders, and also on an auxiliary bus connected to the one-to-one transformer. Two of the feeders enter controlling panels, where by means of oil switches and plugs either can be connected to the incandescent system direct, provision being made at the main station for plugging directly also, or to the primary of a step-down transformer, and the secondaries connected to the incandescent system. This was not intended for regular service, but only as an auxiliary in case of trouble to the incandescent system.

The controlling panels contain also an integrating wattmeter, a voltmeter and primary fuses. The test panel contains the plugging arrangement for the other feeders and a direct-current voltmeter with switches and cord connections for testing the circuits during the day with a primary battery. Back of the switchboard are the inductance-coil regulators, and above these the choke coils and lightning arresters. The choke coils for indoor use consist of 50 turns of wire held together by a wooden spider, and outdoor ones are wound with flat copper ribbon in the same manner, made waterproof, and mounted on glass insulators.

Each sub-station panel in the main switchboard contains two double-pole, double-throw, oil switches from which the wires go to circuit-breakers, and thence to stab or plug switches which are not intended to open the circuit, but for use as selector switches in connection with the oil switches for the individual control of the step-up transformers. The instruments are integrating wattmeters, ammeters for each transformer, and a compensated voltmeter on the feeder containing the regulating transformer. The step-up transformers are of 150-KW. capacity, one for each feeder and one in reserve. One transformer in each sub-station set has ten taps on the primary side by which the secondary voltage can be varied 10 per cent. The secondaries of all transformers go to a separate high-tension board where they are connected to the feeders by means of cords and jacks which are used so that transfers or combinations of either feeders or transformers can be made. One panel in the high-tension board contains a static ground detector and the oil switch and plug jacks for the reserve transformers.

In front of the boiler and engine houses is a three-story office building. On the ground floor are the store and trimmers' rooms, and the carpenter and machine shops. The second floor is occupied by the office, draughting room and small machine shop. The third floor is used for a lamp and testing room and for stores. The lamp room as first built was a part of the small machine shop on the second floor, but was changed three years ago in order to allow more room for repairs. As now arranged, along the outside walls are the benches for cleaning lamps, meters and armatures, and for general repairing. In one corner is the photometer room and lamp bank, one section of which is filled with properly aged lamps to give a known load or a known resistance. The remainder of the lamp room is taken up with the testing tables, racks and switchboard. The switchboard contains plugging jacks and cords for connecting the alternating-current 2400-volt, or 9.6-ampere direct-current service to the test racks, or for testing transformers and motors. The low-tension section consists of double-throw switches, so that the building and lamp-rack circuits can be connected to the exciter buses, or to either phase of the alternating system. The testing bench contains loops of the low-tension buses.

That section of the city within one-half mile of the City Hall has all wires placed underground. The conduit system for this purpose consists of three lines running north, east and west, respectively, each containing nine ducts. These are ample for the city business for many years, but ducts have been rented for telephone and electric light purposes, so that now there is only one duct in one of the conduit lines vacant from the station to a junction pole. The pole lines consisted of two trunk lines from the station branching into smaller lines. These trunk lines consist of pine poles from 50 to 70 feet long, and not less than 12 inches butt, nor 8 inches top diameter. After nearly eleven years, 30 per cent. are still in use. Their principal defect is sap rot, which has loosened the pole steps and cross-arms. A few of the poles were rotted off at the ground line.

Where convenient at the time of installation, the street-lighting, fire-alarm and police-signal systems were run on the same poles, a large part of the construction consisting of the lighting wires occupying the center pins of a six-pin arm, and as the wires paralleled for short distances, when they were changed to alternating, series circuits, trouble from induction resulted. The principal difficulty in this line came from signal systems which are single-wire loops of low resistance and closed on themselves. They would leave the lighting pole and run for a distance on telephone poles, so that the current induced in them by the lighting circuit would induce a current in the telephone line. The trouble was cleared by putting the lighting wires

on the outside pins and transposing the other wires.

The accounts covering the plant investment are summed up under the real estate, buildings, railway, machine shop, steam plant, arc electric plant and incandescent electric plant, the two last ones being made by dividing single investments for electric machinery from assumed conditions. This should be done by taking the amount necessary for street lighting as the investment for the arc plant and charging the balance to the incandescent plant. The one investment item most badly abused is that of lines and poles. This includes not only the poles and wires used for both street lighting and incandescent service, but also all apparatus, such as lightning arresters, choke coils, transformers, and even the meters used in the buildings. The conduit and cable investment is also kept in the same way; in fact, with the exception of the tower, lamp and switch accounts, a part of every one should be charged to incandescent lighting investment, since part only is necessary for street lighting.

The same is true of the operating accounts. They should be divided according to the street-lighting and incandescent service; even the station accounts should not be apportioned according to the kilowatt output. Under contract, the city would pay for the lamps burned on the streets only. No deductions are made for the lamps used in the station and sub-stations, and if "outs" were considered, as they are by a commercial company, there would be far more deductions; for instance, no record is taken of loops or even entire circuits out for parts of the night. The following analysis of the history of the Public Lighting Commission will illustrate these points more clearly, and also show the radical difference in municipal methods in the United States from those in Europe, for the facts stated with regard to this plant are equally true of others.

In the operation of the plant, the engineer's and the electrician's logs give the coal, ashes, water, temperatures of hot well and flue gases, the number of lamps burning and the kilowatt-hours for each day by watches. The number of lamps burning is entered on the electrician's log for both the morning and evening watches, and the total lamp-hours are computed from these entries. At first, the lamp-hours were multiplied by a constant determined four times a year, in order to get the kilowatt-hours, but now the computation is made from voltmeter readings taken at 10 p. m. and 2 a. m. The totals of these readings are multiplied by their respective current strengths and the number of hours burned. The alternating-current arc-lamp consumption is registered by wattmeter. The incandescent load is also measured by wattmeter at the switchboard. These readings, as metered, are entered in the commission's reports, but deductions are not made for losses between the switchboard and buildings supplied, although that is the amount a commercial company would be paid for.

All employees, except those used in the operation of the plant, are used on maintenance and extensions. The method of keeping track of their work is in the usual way, namely, by shop orders which are charged to the proper ledger accounts. All material for most of the cast iron work, mast arms and lamp parts, is bought in the rough and finished by the employees. There is one error, however: the station employees, when on the day watch, do most of the repair work to the station machinery, and it may amount to as much as 10 per cent. of the station wages.

The commission consists of six members, appointed one each year for a term of six years. Consequently, during the life of the commission, there should not be more than eleven members, provided the plan of the framers of the act has been accomplished, which was so arranged in order to prevent any decided change in the management of affairs. As the commissioners constitute the board of directors for the city, their executive duties are of two classes,—the proper handling of the funds, and the impartial dealing with the men.

The design of the act was nearly carried out during the first three years, but in the next four years there were nine men appointed. The commission then remained unchanged for two and a half years, but during the past two and a half years there have been four new commissioners appointed. Consequently, during the life of the plant, the control has been divided as follows:—

Three years by four of the first six commissioners.

One year of readjustment on account of three new commissioners appointed.

Two and three-quarter years which was not entirely harmonious.

Three and one-quarter years by all new appointees.

Two years in which there was a change of four commissioners.

Thus for a period of twelve years ending June 30, 1905, there were three periods of an average of three years each, and each one had a different set of commissioners. These changes in directorate produced changes in plans.

The first change was that of November, 1897, when the employees were put on a daily rate of pay instead of monthly, and the force was materially reduced, although with no material saving in the operating force. There were 28 men in the station crews with a total yearly pay of $17,260, working six days a week. This was changed to 24 men with a total pay of $15,887 per year, working seven days a week. The four places abolished paid $2830 per year, but there was an actual saving of only $1373. Though the amount paid was more, the rate per day was less. If this reduction in pay had been uniform with all employees, there would have been no ill feeling, but a few had their wages increased, seemingly at the expense of many. This dissatisfaction on the part of the employees was still further augmented the next year by doubling the duty of the trimmers, or rather giving them nearly four times the amount of carbons to carry and trimming their lamps every other day.

During this period of reorganization, the trimmers went on strike on account of each being given three additional lamps to trim. At the time of the strike, the term of office of one commissioner expired, and although his name was sent to the council by the mayor, they refused to confirm his appointment. This resulted in the mayor finally nominating one more agreeable to the labor unions. This was the beginning of divisions among the commissioners, lasting through this period of two and three-quarter years and resulting in the resignation of three commissioners in January, 1900, while the oldest in point of service had resigned in October, 1899. Consequently, beginning with January, 1900, there was a commission of six men all appointed by the same mayor. By usage, three of these are Democrats and three Republicans. This personnel remained for a period of two and a half years, but within a year after that, the three Republican members resigned, plainly indicating that all was not pleasant. This is shown by a report made at the December, 1900, meeting of the commissioners by the Supplies and Extension Committee, which consisted of two of the three who resigned. It was shown that the expense for the six months ending December 31, 1900, had increased by $7,594.40, instead of being decreased, as was intended. Of this, $4,662.27 was for maintenance and $2,029.40 for coal, the balance being for small

amounts on other items. The item for depreciation was justifiable, but it should have been kept up during subsequent years.

Table III. is a comparison of expenses between each year and the year preceding, the difference between the items giving the net increase or decrease for the years compared. Thus, between the years 1897 and 1898 there was a decrease of $7,676.04 in some items and an increase of $2,400.59 in others, making a net decrease of $5,275.45. It shows that maintenance, instead of gradually increasing each year, as would be expected, has a large increase one year followed by as noticeable a decrease the next. From these few remarks, we know the decrease between 1897 and 1898 was due to the reduction of the force, but the remaining years are not so affected, the final result making a decrease between the last year and the first. The executive expense shows a general decrease during the first three years, but an increase in the last three, resulting in a small decrease in the last year under the first. The

TABLE III.

Maintenance. Decrease and Increase by Items.	Decrease.	Increase.
Between 1897 and 1898	$7,676.04	$2,400.59
" 1898 " 1899	3,321.86	4,429.84
" 1899 " 1900	3,727.24	774.77
" 1900 " 1901	307.95	3,990.57
" 1901 " 1902	4,254.44	517.26
" 1902 " 1903	654.11	5,072.76
" 1903 " 1904	2,378.24	2,443.12
Executive.		
Between 1897 and 1898	$1,482.72	204.54
" 1898 " 1899	502.98	285.12
" 1899 " 1900	133.34	939.06
" 1900 " 1901	1,287.99	1,070.21
" 1901 " 1902	411.32	578.31
" 1902 " 1903	240.88	342.59
Station.	Decrease in Certain Items.	Increase.
Between 1897 and 1898	$1,867.19	$3,178.27
" 1898 " 1899	873.46	38.00
" 1899 " 1900	2,246.68	399.78
" 1900 " 1901	180.03	5,030.13
" 1901 " 1902	115.33	1,466.43
" 1902 " 1903	3.85	14,017.94
" 1903 " 1904	58.75	3,658.16
Lighting.		
Between 1897 and 1898	$2,992.86	$2,386.95
" 1898 " 1899	2,693.30	2,386.95
" 1899 " 1900	4,605.13	2,572.92
" 1900 " 1901	478.07	1,559.04
" 1901 " 1902	289.08	2,259.83
" 1902 " 1903	871.29	1,261.02
" 1903 " 1904	1 575.78	393 43

station expense should have gradually increased, principally on account of coal, but, after the first two years, there is a slight decrease, followed by a very marked increase.

The lighting expense varies similarly to the station expense, except that in the last year we have a large decrease due, principally, to the installation of enclosed lamps. The preceding year would also have shown the same decrease if what had been saved had not been paid in increased wages to the trimmers. Between the years 1897 and 1904, the lighting expense decreased, but the station expense increased to such an extent that it nearly equals the total increase of operation during the time, and between 1900 and 1904 it exceeds the latter. The station expense increased during the period mentioned, 1900 to 1904, $23,814.70, and during the total time, $22,443.42, while the total expense from 1897 to 1904 increased but $22,952.61.

Table IV. shows the coal consumption by watches, the first being from midnight to shutting down the street-lighting system, the second from shutting down until starting again, and the third from starting until midnight. These amounts are also given in percentages of the whole. The last column is the difference between the first and third watches in per cent. of the third, and is due to the decreased load from midnight until shutting down, caused by reducing the current during those hours. The great difference of the last two years from the others is partially due to the large engine running with only a part of a load in both watches.

Table V. explains some of the peculiarities of Table III. It gives the number of men in the different classes of work, their average pay and the percentage of increase or decrease in wages between the first year and the last. In fact, this table opens to light the real management of the plant. The operating department, with the exception of the trimmers, has been increased by eight men, and six of these are labourers, used, mostly, in unloading coal from cars to bins. Previous to 1900 this work was done by one man. In fact, it has been said that a foreman and three good men could do all the work there is about the station. Table IV. shows that the coal has increased only 62 per cent. in that time, but the labour to handle it has more than tripled. Again, while the operating department has been increased in both men and wages, the latter in a very marked degree, as high as 46 per cent. in one case, the maintenance department has been reduced in pay with the exception of the mechanics in the shop. This is the policy of the present management, who have repeatedly said that any labourer was good enough for electrical repairs, and as a result of such a ruling, two commutators were rebuilt by such men. After running about two months, they were sent back to the lamp room and rebuilt by experienced men.

TABLE IV.

Coal Consumption in Pounds as Given by Watches.

Year Ending	First Watch.	Per Cent.	Second Watch.	Per Cent.	Third Watch.	Per Cent.	Total Watches.	Difference in First & Third.%
1897	5,283,100	35	3,618,950	24	6,130,180	41	15,032,230	14
1898	5,865,530	34	4,278,870	25	6,931,125	41	17,005,525	15
1899	6,054,171	33	4,988,297	27	7,123,962	40	18,166,430	15
1900	5,205,483	32	4,740,464	29	6,395,123	39	16,341,070	12
1901	6,412,000	34	5,002,590	26	7,511,690	40	18,926,280	14
1902	6,950,560	34	5,323,920	26	8,191,510	40	20,465,990	15
1903	9,719,445	35	6,516,625	24	10,147,385	41	26,383,455	04
1904	10,189,768	38	6,107,200	23	10,279,962	39	26,576,930	0087

On July 1, 1902, the towers were reported as needing 35 new stubs, new guy cables on 32 towers, and new elevator cables on 9. All needed new brace-rod bolts and painting. This condition has been confirmed wherever towers have been moved. The line-rebuilding reported at the same time consisted of nearly 10 miles of the more important trunk lines. The necessity of repairs is shown by the "trouble sheets" after every storm. They are so numerous that the day patrol and foreman of the line gang are called out in the night to "shoot trouble" in order to get as many lamps burning as possible.

The result of management is also shown by a comparison of "lamp outs" and their causes. The first record, that of 1897, shows lamp trouble the least, trimmer's fault

TABLE V.

Line.	Classes of Employees.	Men.	1897.	Men.	1898.	Men.	1899.	Men.	1900.	Men.	1901.	Men.	1902.	Men.	1903.	Men.	1904.	Per Cent. Increase or Decrease
1	Engineers and seconds	6	906.66	6	980.00	6	980.00	6	912.50	6	912.50	6	975.62	6	1,021.25	6	1,021.25	+12½
2	Firemen and coal passers	8	605.00	7	638.75	7	638.75	7	638.75	8	638.75	8	638.75	8	730.00	8	730.00	+20
3	Oilers	7	480.00	6	547.50	6	547.50	6	638.75	6	638.75	7	638.75	8	693.50	8	693.50	+46
4	Electricians and helpers at main and substations	8	645.00	7	638.57	7	671.42	7	711.07	7	740.00	8	794.93	8	808.69	8	829.22	+28
5	Trimmers	28	788.22	25	736.80	17	740.00	18	740.00	20	738.50	20	738.50	19	738.99	18	825.62	+
6	Patrolmen, with horses	2	1,140.00	1	1,095.00	2	1,095.00	2	1,186.25	3	1,129.92	3	1,129.92	3	1,129.92	3	1,303.75	+14
7	Laborers at station	5	526.00	9	497.33	7	505.28	7	572.14	12	485.80	9	525.15	9	605.77	11	568.86	+ 8
8	In lamp room	7	667.14	6	639.04	7	614.82	5	563.40	6	495.58	8	542.53	9	592.95	9	617.30	— 7
9	In shop	10	736.90	8	620.13	10	676.08	6	717.29	6	678.16	6	730.33	6	756.41	8	759.02	+ 3
10	Conduit men	2	685.00	2	886.87	2	508.62	3	572.16	2	626.00	2	680.62	2	680.77	2	508.62	—25
11	Line gangs	10	780.00	5	735.55	7	768.85	7	659.53	7	771.32	8	753.15	11	746.93	11	761.16	— 2
12	Executive	9	876.11	8	945.10	7	1,072.28	8	878.35	7	940.11	7	1,034.40	8	1,002.60	8	1,060.94	+21

greater, and line trouble the greatest. The next year has the same relative condition, but the number in each case is very materially increased. This is due to the lamps being trimmed every other day only. The years 1902 and 1903 appear by comparison

TABLE VI.

	1897.	1898.	1899.	1900,	1901.	1902.	1903.	1904
Total lamps trimmed	1,564	1,744	1,868	1,963	2,035	2,133	2,386	2,497
Average per trimmer	59	70	110	109	102	106	126	139
Miles traveled daily	8	7.4	6.6	7	6.4	6	5.8	5.8
Outs, line fault	108	1,479	487	42	110	337	64	44
Outs, lamp fault	56	129	200	818	516	763	1,198	942
Outs, trimmer's fault	88	214	222	498	221	31	33	154

with the others as though some of the outs had been charged to lamps, which were really due to trimmer's fault. The individual record of the trimmers shows that the faults are due to a few only; for instance, during the year ending June 30, 1904, 100 outs were charged to three trimmers, and 38 of these were the fault of two who did not trim them, the patrolman having to do it after starting time, neglecting his own work for the purpose. It appears that the trimmers were looking for the lamps in a saloon instead of on the street.

One of these men was put at work as a labourer when he first came to the commission, but in a few months the superintendent ordered him put at trimming enclosed lamps before he had any experience on open-arc lamps. On account of the neglect of lamps he was discharged, but in March, 1905, he was set at work again, thus putting a premium on poor work and proving the existence of favouritism. There are several similar instances in other departments. A few such men do more damage to good service than is possible from any other source, since their being shielded from penalty

TABLE VII.

	Chicago, Ill.		Detroit, Mich.		Jamestown, N. Y.		Jacksonville, Fla.	
Executive	6.8	6.2	7.5	7.5	18.7	19.7	23.3	13.9
Station	47.0	48.5	49.5	51.3	49.7	51.2	44.7	54.2
Lighting	28.9	28.0	25.5	24.2	16.9	17.1	18.9	19.1

Executive costs in Jamestown include interest on bonds, and in Jacksonville include insurance.

makes the others discouraged. Previous to 1900, two of this class of trimmers were the best the commission had, but with the change in these men. One was put on half-time to give him an opportunity to improve, but within a month the superintendent ordered that he be put on full time, although his record had not improved. Another, when remonstrated with, said he didn't care for the foreman, as he had friends in the office.

In conclusion, some remarks by the writer at the recent convention of the International Association of Municipal Electricians, may properly be added:—

Thus it is seen that it devolves upon the engineer when designing a municipal plant to take into consideration the city government as well as the plant alone. The above description of operation has been given to show the importance of this statement and not to provoke discussion on the management of the Detroit plant, since it is well known that no municipality will acknowledge wrongs among its officers, that is, any investigation is "whitewashed," a policy which produces so much campaign thunder.

During the twelve years the writer has been in municipal engineering, he has had occasion to examine the methods used in 35 cities, and all show the importance of the engineer installing a system of records as well as installing a plant. There is one phase of municipal engineering a municipality does not (I might say, will not) consider, that is a provision for the necessary growth of a plant. The city fathers seem to think that after a plant is installed, all that is necessary for extra lamps is a mast arm and the lamp placed on the street corner, and that no change in the plant is needed. If an appropriation is asked for plant extension, they usually cut the amount so that only part of the work can be done, necessitating make-shifts until the balance is allowed, frequently compelling nearly a double investment.

A comparison of operating expenses for last year, 1904, between Detroit's municipal and a commercial plant running under almost the same conditions, will show many of the defects:—

	Commercial, Per Cent.	Municipal, Per Cent.
Total operating costs.....	129.4	100.0
Taxes and insurance deducted .....13.4 per cent.	.....	.....
Meter and customers' inspection deducted, 7 per cent.	.....	.....
Repairs, customers' service............ 8 per cent.	29.4	.....
Total operating costs, conditions	100.0	100.0
Executive costs	34.0	7.5
Lighting costs	9.6	24.2
Station costs	44.4	51.3
Maintenance costs	12.0	17.0

After deducting over 13 per cent. from the executive expense of the commercial plant there is still over four times as much as in the municipal plant, certainly not all required for a commercial business. The commercial plant was running street lamps at the time that the other items show unnecessary costs. A similar comparison of municipal plants for two years is given in Table VII.

Now, what of the future? Cities owning their plants will soon be compelled to recognize depreciation otherwise than by simply charging off certain amounts each year. These amounts will have to be raised by taxation or bonds, and that at a time when the first bond issue will be coming due. Cities should set aside these amounts when the plants are new, so that they could be used in later years. Cities in which are located the older plants are realizing this, as replacements under the guise of "betterments" are being asked for.

With regard to specifications, do not be afraid to specify, but do it so that a bidding company cannot unload poor material on account of the requirements being ambiguous, and so that a dissatisfied company cannot say the specifications are so rigid that only certain companies can bid. Remember, the specifications are not for a commercial company, but for a municipality, to pass on. A dissatisfied person can always find hearers whom he can induce to make objections. One of our members once said that his town consisted of 40,000 inhabitants and 140,000 politicians. Sometimes it seems as though they were all on hand to watch the opening of bids.

The attention of inventors may be usefully directed to the importance of the early patenting of their inventions in Japan, says "The Journal of the Society of Arts." Imitations in Japan of foreign inventions not protected there by patent are not uncommon. Inventions hitherto regarded as having no direct bearing on the trade of the Far East may turn out to have much to do with it, and unless inventors patent their inventions quickly they may find it too late when they become alive to the necessity of patenting. The Japanese Patent Bureau places in its library the official "Patent Gazette" of the foreign country containing the description of an original invention, after which such invention is unpatentable, and comes under the clause "publicly known," as covered by Article 2 of the Japanese patent law.

Chicago is to have an electrical show during the two weeks beginning Monday, January 15, 1906.

American Institute of Electrical Engineers

Abstracts and Discussion of Papers Presented at the December Meeting at New York

The Relation of Railway Sub-Station Design to Its Operation

By Sidney W. Ashe

THIS paper was limited to a consideration of sub-stations in which high-tension alternating current is received and converted into low-tension direct current. In the operation of a modern railway converter sub-station, reliability of service is of paramount importance, being more important than considerations of first cost, of depreciation, and of maintenance; and in turn the reliability of service is affected to a marked degree by the length of time required to manipulate the various combinations of sub-station apparatus. The following factors were noticed:—

1. The best method of starting converters.
2. The protection of converters.
3. The use of oil-switches when synchronizing.
4. The regulation of load.
5. The best arrangement of switch-gear.
6. The operation of reverse-current relays.
7. The adjustment of load between the sub-stations which feed the same circuit.
8. The noiseless operation of synchronous converters.

1. The best method of starting converters. An essential characteristic of every method of starting converters is ability to start and synchronize in the shortest time without affecting the system generally. The first rule that a sub-station operator must learn is to be ready at all times to carry upon the converters whatever load may come upon the sub-station, this load being limited only by the maximum carrying capacity of the feeder oil-switches. Three methods are usually employed for starting converters, namely:—

A. From the direct-current side.

B. By means of a small direct-connected induction motor.

C. From the alternating current side.

Method A. The converter is started as an ordinary shunt motor, receiving its current either from a shunt-wound generator or from the direct-current bus-bar. A double-throw switch is usually provided so that the converter may receive current from either source. Ordinarily, when started by current from a shunt-wound generator, about two minutes are required to start, synchronize, and connect a 1500-KW. converter to the bus-bar. In emergency cases the machine is started by current from the direct-current bus-bar, and only a minute and a half are required to place it in service. The advantages of method "A" are the rapidity of starting and the smallness of first cost, since it requires but one starting set for all the converters, and the slight expense of maintenance.

The disadvantages of the method consist in a small factor of reliability, and the possibility of a heavy surging of current during the process of synchronizing. The latter disadvantage, however, may be obviated by the use of a simple modification of the switch-gear, devised by H. G. Stott, and now used in connection with the Interborough Rapid Transit Company's equipments. It consists in closing a local storage-battery through the circuit-breaker of the starting bus-bar a fraction of a second before the converter oil-switch closes. The converter then runs practically free from the direct-current side, and self-excited at the instant the oil-switch closes. The oil-switch motor and the tripping-coil of the circuit-breaker are in multiple with the battery when the control-switch on the bench-board has been closed. The oil-switch requires only 0.4 of a second for complete connection, whereas the circuit-breaker operates almost instantly.

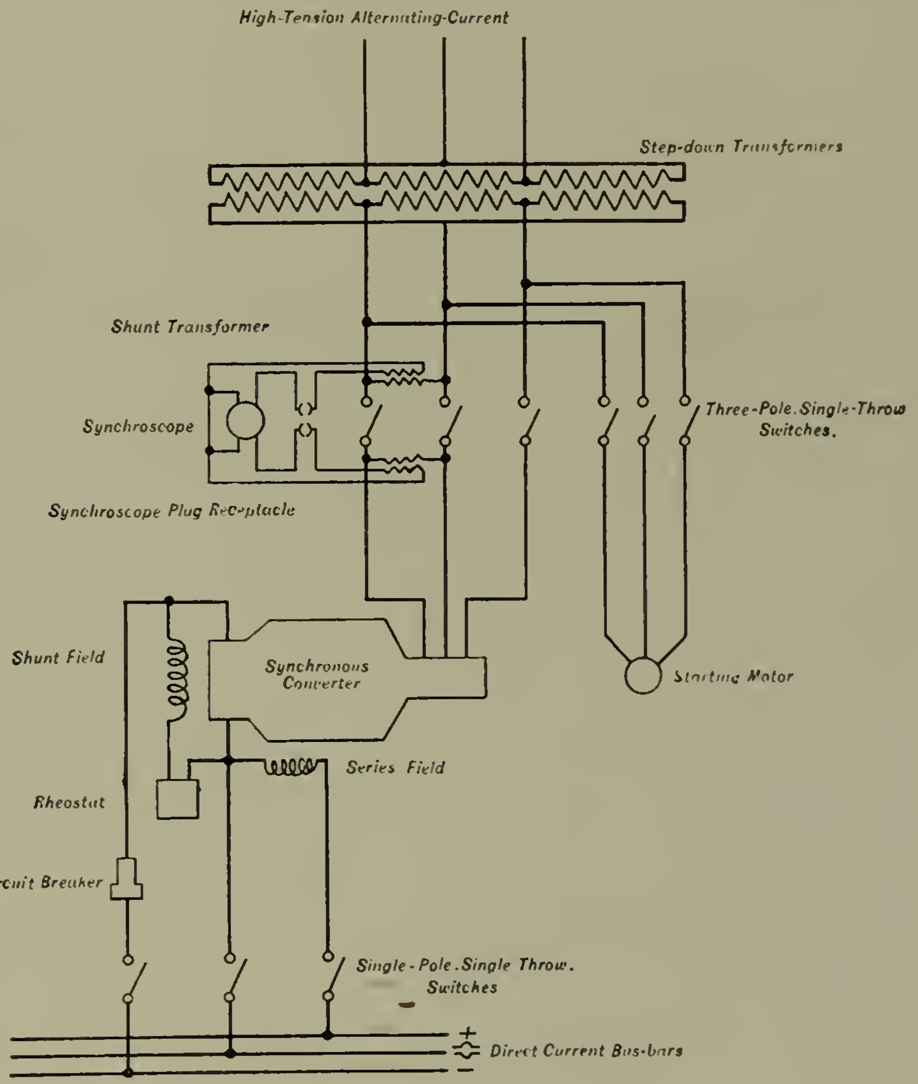
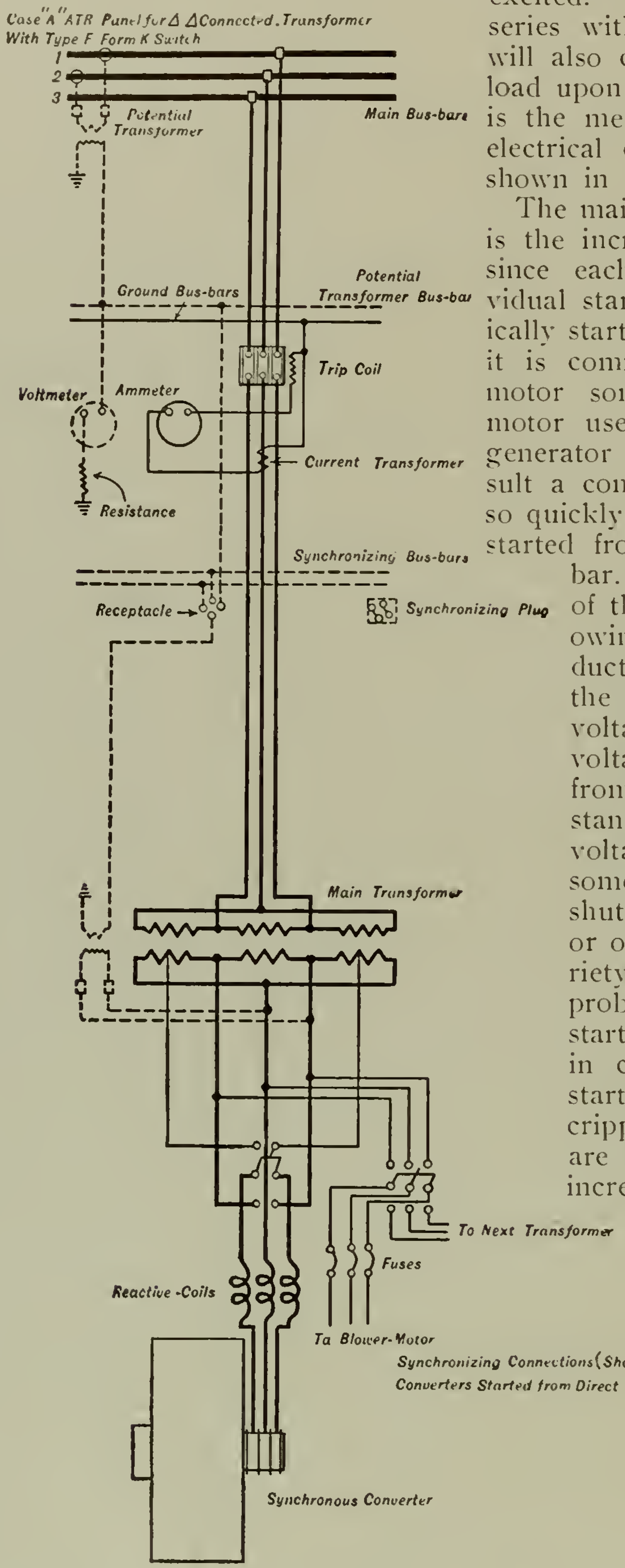


FIG. 1

When the converter is rotating slightly under or above its synchronous speed, and the pointer of the synchronism indicator is moving slowly round the dial, if the local storage-battery switch be closed just as the pointer is approaching zero it is possible to connect the converter through the transformer to the alternating-current bus-bar without the operator being conscious of the fact except from the noise made when the oil-switch closes.



Synchronizing Connections (Shown Dotted) for Synchronous Converters Started from Direct Current End, or by Induction Motor

FIG. 2

Method B. With this method, by means of a small induction motor mounted upon the main shaft of the converter, the converter is brought up to synchronous speed. The starting motor has fewer poles than the converter and therefore a higher normal speed. A variation in speed may be obtained by placing a slight load upon the converter through the medium of a resistance shunted across the brushes, the converter being self-excited. Varying the resistance in series with the converter field-coils will also cause a slight variation of load upon the induction motor. This is the means usually employed, the electrical connections for which are shown in Fig. 1.

The main advantage of this method is the increased factor of reliability, since each converter has its individual starting motor. For mechanically starting the converter armature it is common practice to install a motor somewhat smaller than the motor used for driving the exciter generator in method "A." As a result a converter does not accelerate so quickly with this method as when started from the direct-current bus-bar. One of the disadvantages of this method is the fact that owing to the torque of the induction motor varying with the square of the impressed voltage, a very small drop of voltage will keep the motor from starting at all. For instance, if only 80 per cent. voltage were received, as is sometimes the case after a bad shutdown at the power house, or on the system, due to a variety of causes, it is highly improbable that the converter will start. Another bad feature is, in case of a burn-out on a starting motor the converter is crippled. Other disadvantages are the greater first cost and increased cost of maintenance.

Method C. In this method, the ordinary connections for which are shown in Fig. 2, two sets of taps on the low-tension side of the step-down transformers are connected to a two-way switch, the middle terminals of which are connected to the converter slip-rings. To prevent an excessive starting current, reactance is inserted between the converter slip-rings and the low-tension windings of the transformer. The converter is started as an induction motor by throwing the two-way switch so that the low-potential taps are connected. When the current has fallen sufficiently low—the converter speed increasing—the two-way switch is thrown in the opposite direction, connecting the converter directly to the normal-voltage taps.

It is usual with this method to start converters of 300 KW. or less, from starting taps giving one-half normal voltage. Converters varying from 300 KW. to 1500 KW. are started by voltages of one-third and two-thirds the normal voltage. On the one-third voltage taps, with 25-cycle converters, the current at starting is generally a little less than that at full load.

Owing to the large ratio of the field-turns to those of the armature, high electromotive forces are liable to be induced in the field windings when making use of this method of starting. It is common practice to provide a field-switch which disconnects the windings at several points, as represented by Fig. 3.

With this method no time is lost in adjusting the speed as the converter builds up into synchronism, but an objection to this method is the large current drawn at starting. This, however, is generally at a power factor that yields a correspondingly increased starting torque, and brings the converter up to synchronous speed in a shorter space of time. Another important advantage is the large factor of safety due to the entire absence of starting sets and starting motors. The additional field-switches consume, however, additional time for their manipulation.

The time ordinarily required to put converters in service when using this method is approximately as follows:—

	Seconds
300 KW.	45
1,000 KW.	75
1,500 KW.	120

It is possible to start these converters more quickly. The following times have been recorded, though they do not represent the minimum:—

	Seconds
300 KW.	16
1,000 KW.	40
1,500 KW.	65

This includes the time necessary to close the high-tension alternating-current switch of the converter transformer, the time of starting by means of air-brake lever switches, and the time included in closing the field-switches, the direct-current circuit-

breakers, and finally the line switch.

The chief disadvantages of the method are the high potential generated in the field windings at starting, the large starting current which may affect the regulation of the system, and the necessity for a change in design. The two former disadvantages are minimized by the arrangements previously mentioned. The latter disadvantage, however, necessitates the elimination of the circular dampers embracing the entire pole-piece. A converter constructed in this manner will "hunt" on the slightest provocation and ultimately trip itself out of the circuit. For instance, a short-circuit on some other part of the system, throwing a lagging current on the line, or some slight trouble in the governor of one of the engines supplying it, or anything which may happen to vary the angular velocity of the prime mover, is sufficient to start hunting in a synchronous converter. The starting current is approximately four times that used with methods "A" or "B" for the same capacity machine.

It should be noted when considering the time necessary to start converters that this time depends to a great extent upon the personal peculiarities of the operator. Moreover, the interval of starting for all methods, has been so far reduced as to be adequate to the demands of railway operation. When an excessively steady overload comes upon a station, the operator may easily trip a few of the section-breakers, while an additional machine is accelerating. The cars on the rail section fed by this sub-station will receive slight power from adjoining rail-sections as the $I\ R$ drop will be excessive. The cars will consequently slow down. When the power has been off the circuit for about 20 seconds and the speed of the converter is approaching synchronism, the circuit-breakers formerly opened may be closed, and the other section-breakers and switches opened. In this way trains may be kept moving during the time required to start, synchronize, and place on the bus-bars this additional machine. Passengers in the cars will hardly be conscious of what has occurred.

The Protection of Converters. In the design and installation of circuit-breakers the inductance of the system is usually relied on to prevent an excessive rise of current during the interval of time elapsing between a short-circuit and the opening of a circuit-breaker. This, however, is not sufficient protection; for an excessive short-circuit in the system, say during light load when only one machine is operating, will often cause a flash, accompanied by a shrill sound, around the commutator of the converter. At first one might think that a reactance-coil of low ohmic resistance could be placed in series with the breaker to minimize this effect; but a coil of constant reactance, resistance, or self-inductance, could not entirely meet the conditions, owing to the variability of the time-constant of the circuit. For instance, the self-inductance and resistance would vary with the distance from the sub-station in which the short-circuit occurred. Proper conditions, however, might be approximated and a coil designed which would partially protect the converter.

Where sub-stations are equipped with storage batteries which float on the system, there is a tendency for the storage-batteries to bear the brunt of the load, in case of short-circuit, permitting the converter circuit-breaker to open, followed shortly by the opening of the battery circuit breaker. This, however, does not always prevent the converter from flashing over, owing to the fact that the velocity of chemical action at the electrodes of the battery, and the limitations of the velocity of migration of the ions of the electrolyte are insufficient to prevent this action. Theoretically, the converter bus-bar voltage would drop, the battery carrying the peak of the load. As a matter of fact, the battery does not always perform this function.

The Use of Oil-Switches when Synchronizing. The superiority of oil-switches over air-switches for opening and closing alternating-current circuits is due to several causes, namely, the smothering action upon the arc by the oil, the rupturing of the circuit at the zero point of the current wave, the absence of leakage between contact points, and the small dimensions of the switch. Electrically operated oil switches, however, have a few disadvantages which, while not vital, are worth mentioning.

With an oil-switch, the time required to close the circuit varies with the voltage of the local storage-batteries. When this voltage falls below a certain point, the switch fails to operate. Such switches are guaranteed to operate over a considerable range of voltage, something like 125 volts to 70 volts, but several instances have been brought to the attention of the writer in which switches have not operated when the voltage has fallen below 95 volts. This characteristic is extremely objectionable, for it obliges the operator to re-synchronize, inasmuch as the general sub-station rule requires the starting over again of all auxiliary apparatus when an oil-switch fails to operate. Another objectionable feature is that sometimes oil-switches fail to lock when closed by the switch-motor, opening again and closing subsequently when the converter is perhaps as much as 60 degrees out of synchronism. This performance is characterized by operators as "looping the loop." One can readily imagine what happens when a converter that is considerably out of synchronism is closed upon the circuit, making what is termed "a

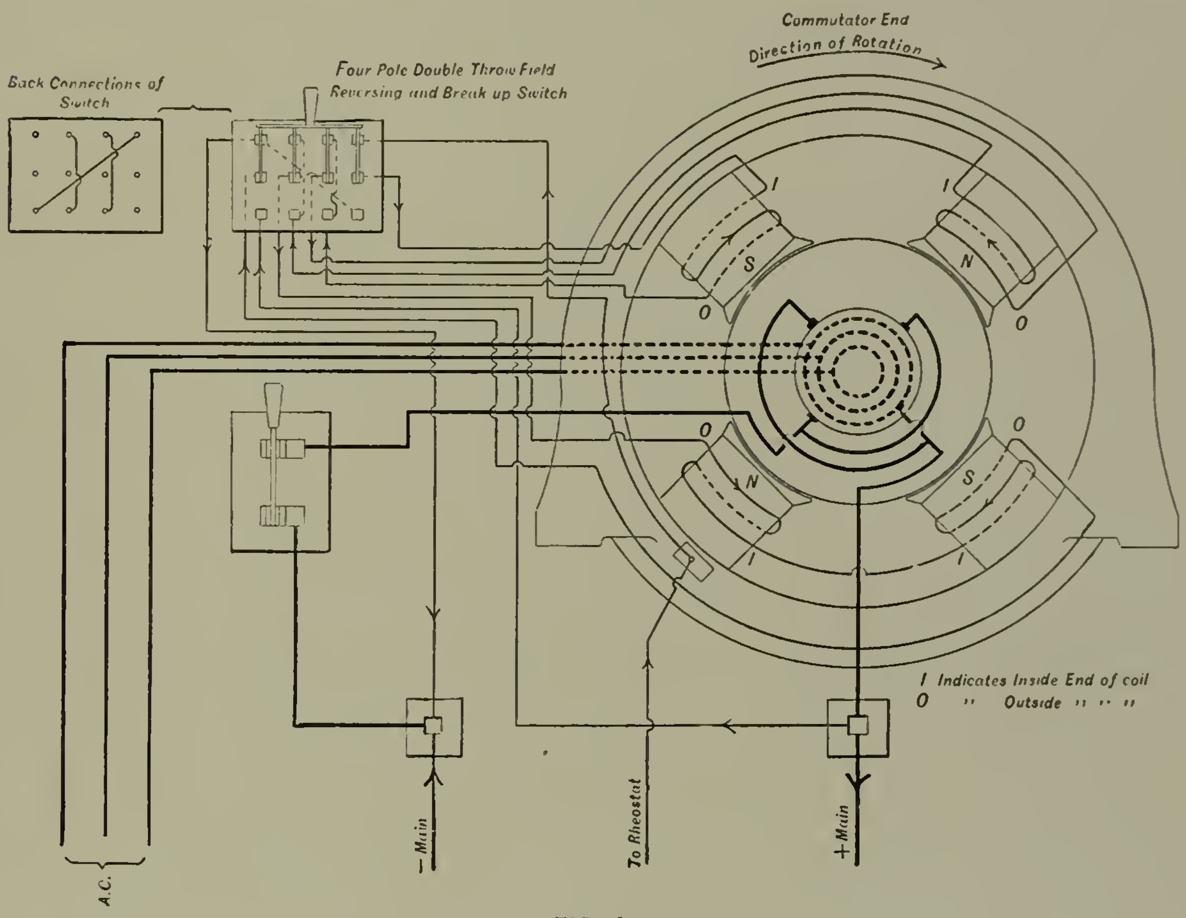


FIG. 3

bad shot." This may do considerable damage. These troubles, however, are not of frequent occurrence and an operator who is familiar with the "individuality" of each switch soon learns to test it frequently, as well as to keep his storage-batteries well charged, and thus to minimize these disagreeable characteristics.

The Regulation of Load. Railway operation does not call for as close a voltage regulation as is requisite for electric lighting circuits. Economic operation, however, demands that converters be run on as constant a load as possible. The general use of storage-batteries for load-regulating in railway work seems to have been retarded, owing to their objectionable features, for instance, their acid fumes, the necessity for special wiring, and their heavy depreciation. In addition their enormous first cost has placed them actually out of competition with synchronous converters and generating apparatus. The usefulness of storage-batteries in railway work is being more and more appreciated, as evidenced by their recent applications.

An interesting development in connection with storage-batteries is a carbon regulator put to use during the last year. It consists of a variable carbon resistance which is used in connection with pilot-cells and an exciter, to vary the excitation of the field coils of a booster.

Referring to Fig. 4, *H* is a solenoid carrying the total generator load, which acts on a soft-iron plunger suspended from the lever *A-B* of the carbon regulator. At the other end of the lever is a spring *S*, whose tension is adjustable. *K* and *L* are piles of carbon discs on the opposite sides of the fulcrum *C* of the lever. The resistance of these piles is altered by slight variation in mechanical pressure, produced by slight fluctuations of current in the coil *H*. The details of the electrical connections are self-explanatory. The battery booster is represented by *D*; *F* being in its field-coils. *E* is a small exciter, whose field-coils, *M*, are connected to the carbon regulator as shown.

Consider the operation of this regulator. As the lever-arm is raised or lowered, the resistance increases in one arm and decreases in the other, causing wide variations in voltage across the exciter field-coils, the direction and intensity of the current in the coils varying accordingly. The action is somewhat analogous to that of Wheatstone's bridge.

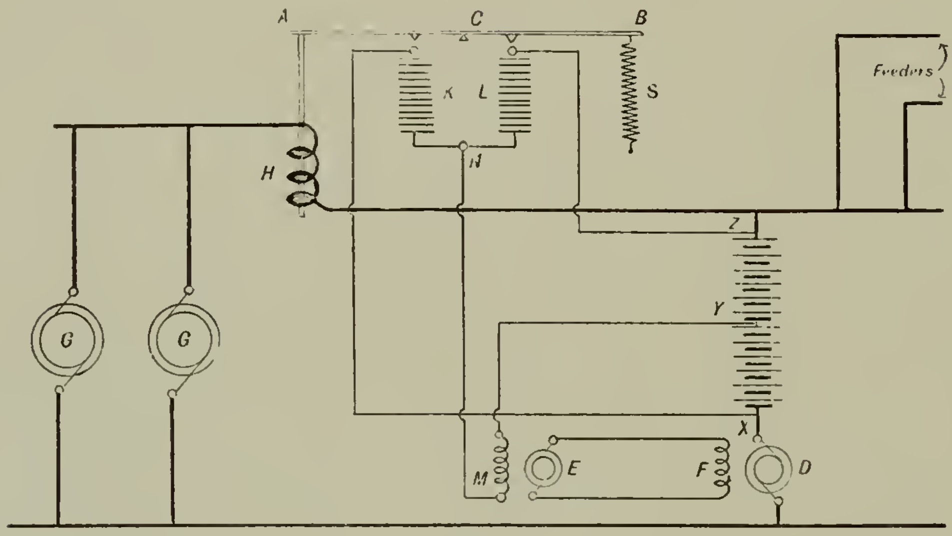


FIG. 4

With the polarity of the booster changing and its field excitation varying in intensity, it is possible automatically to charge the main battery or to raise the battery voltage so as to carry part of the load of the bus-bar. By limiting the motion of the lever-arm it is possible to limit the load which the battery will carry under extreme conditions. With this system close regulation of the load on the converter is obtained.

The Best Arrangement of Switch-Gear. There are two distinct arrangements of switch-gear, their adoption depending upon the capacity of the sub-station. With one arrangement, which is especially applicable to small sub-stations, all of the switch-gear is located upon the main floor with the converters and with the transformers. The other method, which is usually employed in stations of large capacity, consists in locating all the manually operated switches, except the negative switches, in a switch-board gallery.

It is worth noting that in the first case, where all the switching apparatus is located on the same floor with the transforming apparatus, the station attendance is minimized; for the operator may also perform part of the duties of station foreman, and the converter tender may also perform the duties of janitor, thus dispensing with two men; but with this system it is difficult to keep the switch-gear clean, and in case of trouble the operator is too near the converters to act with unconcern. On the other hand, this system reduces the expense of wiring to a minimum, allows excellent ventilation, and results in a very compact station.

Where a switchboard gallery is employed, the operator is able at a glance to scan the whole station, a great advantage in case of trouble. He is relieved of the fear of personal injury; he is less hampered, and more comfortable, and can better perform his duties. But the expense of wiring is greater and the ventilation inferior.

It is becoming the standard practice to construct the switchboard in there distinct sections, namely, a controller-board from which the oil-switches are operated, a set of machine-panels, and a set of distributing-panels. The positive direct-current bus-bar forms a connecting link between the machine-panels and the distributing-panels. This system is sometimes modified in small stations.

Various arrangements of circuit breakers are employed; in some cases they are mounted directly upon the switchboard panels; in others distinct and separate compartments are used. The latter is preferable if the expense be justified; for it disconcerts an operator to see the flash of an opening circuit-breaker. It has become quite common to separate the negative switches from the positive switches, the reasons for which are obvious.

A feature worth mentioning is the arrangement of a circuit of lamps on the switchboard, and their feeding from the local battery circuit, so that in cases of failure of power at the power house there may be sufficient illumination in the evenings for the operator to manipulate the board. Upon the same circuit a complete set of signal-lamps should be installed to indicate whether switches and circuit-breakers are open or closed.

The Operation of Continuous Reverse-Current Relays. Much criticism has been directed against continuous reverse-current relays, owing to their sensitiveness, the amount of adjustment they require, and their inability to perform their service at all times. While these criticisms are partly warranted, the fact remains that such relays are better than no protection at all.

An operator is supposed to try the relay controlling the machine circuit-breaker each time a converter is disconnected from the bus-bar. The field rheostat of the converter is cut

in entirely, the converter dropping its load. The positive bus-bar voltage being slightly higher than the machine voltage, the reverse-current relay is energized, closing the local-battery circuit through the tripping-coil of the circuit-breaker, which should open instantly.

Sometimes when a converter is being placed on the bus-bar its voltage is slightly lower than that of the bus-bar and consequently it "backs out," the circuit-breaker being tripped by the action of the reverse-current relay. This feature is disagreeable, but it tends to make the operator more careful.

If reverse-current relays were not sensitive they would be practically worthless. Hence the features which appear to make the instrument objectionable are necessary elements of its successful application.

The Adjustment of Load between Sub-stations that Feed the Same Circuit. Where all sub-stations are equipped with converters of the same capacity, it is desirable to have a definite rule governing the adjustment of power-factor of converters, in order that the rail load may automatically distribute itself to the proper sub-stations. Such a rule requires the adjustment of the power-factor of all converters so as to be unity at full load; but it fails where applied broadly, owing to the practical impossibility of finding any two converters of the same capacity, although manufactured by the same company, with identical characteristics, and equal brush contact resistances. This rule is usually observed, however, with discretion by sub-station operators, and its observance yields good results. But if the rule be adhered to rigidly, the results are not altogether satisfactory.

For instance, assume two converters operating in multiple between a common alternating-current bus-bar and a common direct-current bus-bar. Assume also that the field resistances of the converters are adjusted for unity power-factor at full load. When the load upon both machines is greater than the combined full-load capacity of each machine, one converter may draw more than half the load. Also when the total load is less than the combined normal load of both machines, the other converter may absorb the greater proportion of the load. This condition is aggravated by the resistance of the converter field-coils changing with the temperature, and also by the maintenance of the converter direct-current brushes.

When an individual converter in a sub-station is disconnected from the direct-current bus-bar, it does not follow that the original station load will distribute itself over the remaining converters operating in multiple. Moreover, when an additional machine is connected to the circuit, the sub-station will draw more of the load from the adjoining sub-stations. The energy in this way surges back and forth with each operation. It is obvious, therefore, that it is practically impossible to frame a rule of this character which may be adhered to rigidly. If storage-batteries are employed as a method of regulation, keeping the individual load upon the converters practically constant, this rule would apply more generally; but where the energy fluctuation upon the converters varies from quarter load to 50 per cent. overload and sometimes 100 per cent. overload, it is obvious that the previous rule will not apply. The same reasoning holds good in the case of a sub-station equipped with machines of different capacities.

Noiseless Operation of Converters. The operation of converters is usually accompanied by a shrill and disagreeable sound, probably the result of vibrations set up in the armature-core teeth by the varying electromagnetic conditions of the circuit.

To demonstrate this, a converter was driven by a separate belt-connected shunt motor, and the speed was adjusted to 1800 revolutions per minute. The converter was a four-pole machine, so that this corresponded to a frequency of 60 cycles. The converter field coils were unexcited and the machine operated practically without noise. Upon exciting the field-coils this shrill tone became audible, and then increased in intensity until upon over-excitation it became very loud. This would seem to indicate that the phenomenon is purely magnetic, and that it might be obviated or at least modified by proper design.

Some Considerations Determining the Location of Electric Railway Sub-Stations

By C. W. Ricker

No attempt was made in this paper to define the conditions under which indirect distribution, through the medium of transformer sub-stations, is more economical than direct distribution from one or more generating stations containing prime movers. It was assumed that because of the size of the railways to be considered, and the local conditions determining the cost of generating power, the indirect method of distribution had been selected as offering the best economy in commercial operation, and a general method was outlined for determining the number and location of sub-stations.

In many cases, perhaps the majority of cases, a general solution of this problem is quite possible. Most of the large electric railway systems now in existence are the result of development not foreseen by their original projectors, and there is little reason to believe that future systems will be very widely different in this respect, but probably they will continue to grow by extensions and consolidations depending upon the distribution and development of local centers of industry and population.

For convenience of discussion, electric railways large enough to require indirect distribution may be classified as follows:—

1. Large simple networks, serving a single community.
2. Long single lines or groups of such lines, connecting separate communities or different parts of a very large one.
3. Complex networks, with connecting lines, serving a city and its suburbs.
4. Several networks with long connecting lines, serving separated communities.

Railways of the last-named class are usually consolidations of the local systems of neighboring cities or towns, and interurban lines which frequently furnish power for lighting and general uses in the towns served. There are usually well-marked centers of load which, together with local business conditions, determine the position and equipment of sub-stations.

Railways of class 3, those serving a large city and its suburbs, are also most often the result of the consolidation of separate lines and networks. While the large central network belongs in class 1, the outlying districts present a difficult problem to the engineer, for he must anticipate the direction, character, and sequence of growth so as to provide for them. This requires an intimate knowledge of local conditions, both industrial and social, and in addition he has need to be something of a prophet to foresee the changes which the building of new lines and the starting up of new work may produce. The problem is a local and particular one, and must depend mainly upon individual judgment for its solution.

Classes 1 and 2 can be treated more generally. Take first the case in which a large network, or long

line or group of lines, is contained wholly within a large city, so that a fairly uniform schedule can be operated over the whole, and the mean load upon each mile of road is approximately uniform throughout the system, at any given time. It is required to adjust the cost of losses in the primary distribution, the secondary distribution, including the track, and the sub-stations, the fixed charges upon each of these three divisions, and the cost of sub-station attendance, so that their sum shall be a minimum, with due regard to the conditions of regulation and continuity of service.

As the density of the load in such a system is very great, the unit of sub-station equipment may be made large enough, so that at the time of least load one unit per sub-station may be operated at or near its best efficiency. Hence the sub-station losses per kilowatt-hour may be considered constant.

The aggregate capacity of the sub-stations will equal the capacity of the generating station plus the sub-station reserve capacity, if any is necessary, which will not exceed one unit per sub-station. The greater the distance between sub-stations, the larger the sub-station unit will be; hence, the cost of sub-station apparatus will decrease as the number of sub-stations increases, until the largest practicable unit is reached. The same is true of sub-station land and buildings.

The cost of sub-station attendance will depend only upon the number of sub-stations, as the same number of attendants is required in a small as in a large sub-station, unless the cost of land makes it necessary to double-deck the sub-stations, which will cause a sharp rise in the cost of attendance when the number of units becomes greater than can be placed on one floor.

When direct-current motors are used, the secondary voltage is fixed by conditions of standard practice. The secondary conductors may be proportioned by Kelvin's law, subject to the limiting condition that the lowest potential shall be enough to allow the required acceleration. As the number of sub-stations increases, the cost of the conductors will decrease rapidly. The energy losses in the conductors may be constant or decreasing. The primary distribution in this case must be by underground cables. The primary voltage will be determined by the relative cost of copper and insulation, and should be as high as is consistent with safety. Hence the losses per mean kilowatt in the primary distribution may be considered constant. The total weight of primary conductors will be practically independent of the number of sub-stations, depending upon the total energy and the mean distance of distribution, and may be determined by Kelvin's law.

To obtain the greatest reliability of service, each sub-station should be fed directly from the generating station by at least three cables, and in the case of a wide difference in the number of sub-stations considered, the total cost of cables and conduits would be somewhat greater with the larger number of sub-stations as more and smaller cables would be required. Otherwise, the cost of the high-tension distribution and the losses in it may be considered constant.

Neglecting those quantities which are constant, the fixed charges on sub-station land, buildings, and apparatus, and the cost of sub-station attendance increase as the number of sub-stations increases; the fixed charges on the secondary distributions decrease and the losses in the secondary distribution decrease or remain constant.

The various losses and charges upon which the solution of the problem depends may then be considered as constants or variables, dependent directly upon the number of sub-stations and inversely upon the distance between sub-stations. These quantities may be reduced to a common base of annual kilowatt-hours, and curves representing them may be drawn with respect to the number of sub-stations as one co-ordinate, and a summational curve may be drawn which, if the premises are rightly chosen, will indicate the number of sub-stations at which the sum of the various charges is a minimum.

In a far greater number of railways the load is not uniform throughout the system. This is true especially of the long interurban railways using a comparatively small number of heavy train units. The load at any given time is concentrated upon parts of the system, or travels from end to end of the long lines. In such a system, the aggregate capacity of the sub-station apparatus, in operation at any given time, is greater than that of the generators; hence, the load factor of the sub-stations is unfavorable, and in most cases the power factor of the system is low.

In a solution by the method outlined in this paper, several new curves must be drawn in addition to those named, the first showing the all-day losses in the sub-station apparatus, these increasing with the number of sub-stations; the second showing the losses in the primary transmission lines, these losses also increasing with the number of sub-stations, due to the greater length of lines and to the lower power factor; and the third showing the fixed charges on the primary transmission lines.

The last two curves are relatively much less important. It is possible by compounding or automatic adjustment of fields, to keep the power factor of the synchronous converters very near unity, making the transmission losses more nearly constant and independent of the number of sub-stations. In such systems it is not usual, and seldom practicable, to use separate feeders from the generating station to each sub-station, and the primary distribution is usually by overhead lines, generally supported on poles which are used for other conductors as well. But with all the sub-stations along a single line of railway, or a group of such lines connected to one transmission line, the additional cost of extending the line for a greater number of sub-stations will usually be but a small part of the whole expense. So, for at least a preliminary consideration of the problem, the last two curves may be omitted and the same quantities used as are considered in the solution for a road having a uniform distribution of load, with the addition of one containing the all-day losses of the sub-station apparatus.

In systems consisting of long lines with infrequent train service, the cost of attendance and all-day losses in converter sub-stations often become so great that the regulation in secondary conductors economically proportioned for standard direct-current voltage will not permit the operation of the required schedule. The usual remedy is to set the sub-stations nearer together, though at the cost of operating economy.

If other conditions still make the use of standard direct-current equipment desirable, it would seem that better economy could be obtained by lengthening the sub-station sections and using boosters, just as has been found profitable in the supply of such lines of less length from direct-current generating stations. The fixed charges on, and losses in, the boosters should then be included in the curves of sub-station apparatus.

In the discussion of the method of treating the problem of sub-station location herein suggested, the usual type of converter sub-station, with direct-current, secondary distribution has been kept in mind. But the

method is no less applicable to a complete alternating-current system with static sub-stations, in which case the curves of sub-station losses, attendance, and fixed charges, all become flatter, while the higher trolley voltage available permits a wider spacing of sub-stations, without exceeding the limiting conditions of regulation—all of which indicate a better efficiency of sub-station apparatus and secondary distribution, in roads of low and non-uniform load density.

DISCUSSION

After the reading of the papers, the president, Dr. S. S. Wheeler, called upon H. A. Lardner to open the discussion. Mr. Lardner said in part that among the disadvantages not noted by Mr. Ashe for the method of starting rotary converters from the direct-current side may be included the fact that under some conditions direct current is not always available, as for example, when sub-stations are entirely shut down at night, as in the case of some interurban railways. In that event no direct current is available for starting the converters in the morning, unless storage batteries are included in the equipment.

In describing the method of starting rotary converters by means of a small induction motor mounted upon the shaft, the author does not call attention to the fact that many rotary converters, at least of the smaller sizes, do not provide such convenient methods of assisting the synchronizing of the machines as resistance across the brushes, nor in series with the field coils. A much more common method of synchronizing with the small motor is to allow it to speed the converter up to a point above synchronous speed, then open the motor switch, and catch the converter as the speed falls past the point of synchronism. Mr. Lardner was not prepared to say that the refinement of a resistance in connection with this method is an expense which is prohibitive, but thought that this is usually found to be the case in stations where the capacity of the rotary converter is less than 500 K. W.

The method of starting the rotary converters from the alternating current side, described as method C, has many advantages, amongst which are great simplicity and the omission of special apparatus. The introduction of taps running from the middle points of the transformers is a very slight modification, and the double-throw switch required is also a small matter. The division of the fields is not seriously objectionable. There are many rotary-converter installations of 500 K. W. and under, operating at 25 cycles, where this method of starting is very satisfactorily used, and where hunting is practically unknown.

The disadvantage of method C in drawing a large current from the line is not serious when it is used for starting the sub-station apparatus in the morning, when no direct current is available; and even though it becomes necessary to employ this method in an emergency when many cars are depending on the particular sub-station, it is always possible to trip feeder circuits and otherwise lighten the load on the sub-station until the rotary converter can be started. As Mr. Ashe showed, the time required with this method is very short, especially in the smaller sizes of machines.

Referring to Mr. Ricker's paper, Mr. Lardner questioned whether, in the case of interurban railway installations, better economy could be obtained by lengthening the sub-station sections and using boosters. For instance, on a given interurban road, the sub-station may normally operate with two rotary converters of, say, 300-KW. capacity. The entire capacity of this sub-station may be momentarily required by the starting of cars at the extreme end of the section fed by this sub-station, and schedules frequently work out in just this way. If it were attempted to install boosters to handle the load at the extreme ends of the section, they would have to be of very considerable size, especially as to commutator capacity, even though subjected to severe loads for but short periods of time. He thought that when the added cost of the boosters, their switching apparatus, and maintenance, and the additional space required, were all considered, their use would not be justified by other savings made in first cost and operation.

Referring to the last paragraph in Mr. Ricker's paper, Mr. Lardner said that while it is true that in alternating-current systems with static sub-stations the trolley voltage available permits a wider spacing of those stations, yet it must be remembered that owing to the characteristics of the alternating current, the usual saving in connection with increase of pressure cannot be applied, owing to the fact that the drop in both the rail and the overhead conductors, with an alternating current, is considerably in excess per ampere of that for direct current.

W. I. Slichter, discussing Mr. Asche's paper, called attention to another method of indirect starting of rotary converters by the use of a single-phase commutator motor. The alternating voltage of a rotary converter being approximately the voltage which is suited for a single-phase commutator motor, by putting a reactance in series with such a motor an easy means can be attained of regulating the voltage and speed, and it would be easier to obtain the proper speed for throwing the converter into synchronism.

Mr. John B. Taylor thought there seemed to be a general impression that the purpose of the reactance coil, as mentioned in method C of Mr. Asche's paper, is to permit starting from the alternating current side. As a matter of fact, the reactance coil is used for several reasons,—to permit automatic compounding; to compensate partially or wholly for the line drop and drop in the transformer and converter itself; it also allows the converter to run under variable load with comparatively slight changes in power factor so that it is almost unnecessary for a station attendant to make any changes in the field rheostat at any time during the day. It also readily permits the division of load between converters. All such factors as brush resistance and field resistance become of small importance when reactance coils are installed. There is no more difficulty in obtaining adjustment of load between converters than in any other class of direct-current machinery. It also permits the running in parallel of machines of different ratings and of different manufacturers.

Referring to the disturbance in voltage on the system due to the starting of rotary converters, if it is a simple railway proposition there is not enough disturbance, starting the converters at, say, one-third voltage, to make any trouble. If it is a lighting system in which the lights are also fed from rotary converters, it becomes a more important point, but there are comparatively few such systems in this country, and, as a rule, they are large and have many converters in service, all of which tends to keep the voltage up, so that even in this case it is doubtful if it would be a serious matter to start a converter in this way. To bring the current to the lowest possible value, a still lower voltage tap might be employed.

The matter of the breakdown of field has been given more prominence than, in Mr. Taylor's view, it deserves. Such breakdowns usually occur in cases when the best practice is not followed. In the latest practice the ends of all fields are left up at the time of starting, and the increased voltage is not over 2000 volts

to the group, and there is no more reason why it should break down than any other direct-current machine.

As far as the matter of bridges is concerned, there are a number of machines in service which have bridges or damping coils, and that start satisfactorily from the alternating-current end, and there seems to be no reason for taking them off. There are also numerous converters for these bridges, and the statement that they are liable to hunt is perhaps overdrawn. The matter of drawing a dividing line between starting at half voltage and one-third voltage is more or less arbitrary.

H. G. Stott said that one of the important points in the operation of synchronous converters has been omitted in the papers, namely, the line drop. The synchronous converter is operated with a line drop of 12 per cent., and there is always a difficulty in holding it in synchronism, and its operation generally will be very unsatisfactory. This point applies equally to the method of starting from the alternating-current side. If the line is fairly well loaded up, and there is a drop approximately of 10 per cent., and a large converter is then started, with a line capacity, a drop may be caused sufficient to start the other converters hunting and induce a heating of the brushes. That is the limiting condition in the location of sub-stations; that is to say, we must not feed at the maximum more than 15 per cent. drop on the line.

President Wheeler remarked that a somewhat similar problem, but in a much reduced degree, was presented in connection with the operation of direct-current machines in multiple a good many years ago. Some annoying experiences were had with "loop-the-loop" in 1882-1883, when Mr. Edison started his large station down town, New York. He had, it will be remembered, some dynamos of fairly large size for those days, but at the time set for lighting up, namely, on September 4, 1883, the dynamos had not been operated in parallel, and when the attempt was made to do so, it was found to be impracticable. It was within the speaker's personal knowledge that when Edison made this discovery he used the expression, "My God, Bradley, can we run or can't we?"

It was found that the engines would not run together on account of the sensitiveness of the governors. After studying the matter for a time, special shafting was made by which to tie the levers of the governors togeteher so that one steam engine could not go fast without the others going fast.

Prof. R. B. Owens was much interested in the title of the second paper, because the main consideration in connection with the location of electric railway sub-stations seems to have been omitted, namely, voltage. There are two great systems of operating railways for heavy traffic; the alternating-current system, and the direct-current system with sub-stations. It is stated that manufacturers are ready to furnish rotary converters of 1000 volts, possibly more, and also bipolar motors that will operate successfully at such voltages. If this be true, it affects the whole question of sub-station location most materially. The gist of the whole matter seems to be, how far can the direct voltage be carried? Can rotaries be obtained that will operate successfully at 1000, 1500 or 2000 volts? Can motors be operated at those voltages?

Instead of sub-stations with a load factor of a few per cent., perhaps we can get sub-stations with load factors of a decent percentage. The question lies in the design of direct-current machinery in large units to operate successfully under conditions met on traction work at high voltages.

Prof. C. P. Steinmetz believed, with many other people, that for a long time to come, if not for ever, the largest number of railway sub-stations will remain converter sub-stations. The rotary converter railway sub-station can be divided into two typical classes,—the sub-station and a large, high-power distribution system, as the railway sub-stations of the New York City Railway and interurban sub-stations. In the first class the loss between generating station and sub-station, and the drop of voltage between sub-stations is very small. The sub-stations contain a large number of large units which run practically always at steady full load. The individual momentary variations of load are not perceptible in the sub-stations to any great extent, and the daily changes of load are taken care of by varying the number of converters, and the possible variations of voltage due to line drop is insignificant. Therefore, automatic voltage-controlling devices, such as compound fields and reactive coils are not necessary, and, in the case of shunt-wound converters, would tend to racing in the event of the direct-current system feeding back into the converter sub-station, which danger, due to the smaller resistance between sub-stations, is greater here than in the case of interurban sub-stations.

In the interurban systems the variations of load, on the other hand, are impractically large for the ordinary method of voltage control. Therefore, these cub-stations utilize powerful series fields and reactive coils. This is called phase control.

In the operation of a converter sub-station, the most important matter is the starting of the converters. The starting from the alternating current side gives the severest jolt on the system, especially when started at full load. In present practice the converter is started either by a starting motor or from the direct-current side or synchronism. The method of starting can be sub-divided into two large classes,—those methods which require synchronism and those which do not require synchronism.

The method of starting by synchronism was introduced largely to avoid shock on the system, but recently the tendency has been strongly away from that, and at least in interurban systems it may almost be said that this method has failed. It has failed because at the times when rapid starting is most essential, when there is trouble on the system with heavy overloads when the direct-current voltage begins to sag down to nothing, and when in the alternating-current system the voltage goes up and down, you cannot safely synchronize, because when the converter is started, its speed, as obtained from the starting motor, see-saws rapidly up and down, and the alternating frequency may then vary, seeing which, the station attendant throws the switch. * * * In large metropolitan substations the difficulty is largely reduced because the voltage has steadied on the alternating side as well as on the direct-current side, and synchronism can then be obtained. At the same time, if one throws in out of synchronism, the result is much more disastrous inasmuch as there is almost no resistance between the generating station and the sub-station or between the sub-stations, and all the momentum of the whole system feeds back into the converter, thus reversing the converter at full velocity. This may happen with the most skillful operator.

Probably the compromise arrangements have been developed to reduce the jolt on the system, for instance, to start from the direct-current side and bring the converter up to speed near to synchronism, approximately, possibly a little above synchronism, then disconnecting absolutely from the direct-current side and closing the alternating switch. The converter drops in almost instantly without appreciable jolt.

With regard to the subject of the storage battery, Professor Steinmetz said that it was a very useful and desirable element in a railway system. The only objection to its use and one which has practically prevented its introduction in most railway systems, especially in interurban systems, is its cost, which is so great that an interurban railway cannot pay for it, or if it could, it would not be sure to earn sufficient revenue to pay the interest on the investment in the battery.

Messrs. E. H. Hewlett, D. B. Rushmore and Wm. McClellan also took part in the discussion.

The next meeting of the Institute, to be held on January 26, will be given up to a paper on "The Future Central Station," by H. G. Stott, superintendent of motive power of the Interborough Rapid Transit Company, of New York. For the meetings of the succeeding months the following subjects have been announced:—

February 23, "Telephony"; March 23, "The Influence of Load Factor on the Design and Success of Hydro-Electric Plants"; April 27, "High-Tension Underground Cables." 1. 23, "The Influence of Load Factor on the Design and Success of Hydro-Electric Plants"; April 27, "High-Tension Underground Cables." 1. "Standardizing Rubber-Covered Wires and Cables," by John Langan, Associate A. I. E. E., Okonite Company, New York.. 2. "Some Comments on Present Underground Cable Practice," by Wallace Clark, Associate A. I. E. E., engineer of the wire, cable, and tube department, General Electric Company, Schenectady, N. Y.; May 15, annual meeting. This will be a business meeting; no technical papers will be read.

On June 26-29, 1906, the annual convention will be held. Papers for this meeting have been promised by H. C. Wirt, W. S. Franklin and John B. Taylor.

Platinum wire is rapidly becoming a standard for protective fuses in electric circuits of small current capacity. The fact that this metal does not oxidize at any temperature greatly increases the surety of the interruption of the electric urcuit only at the predetermined point. For telephonic and telegraphic circuits it is admirably adapted, as the small section of metal required makes the cost insignificant.

Over 175,000 independent telephones are used in Indiana. The exchanges number 368, and the total investment is $11,605,873.

The Recent New York Electrical Show

THE electrical show held at Madison Square Garden, New York, last month, was as a whole somewhat disappointing from a technical point of view, the majority of the exhibits being familiar ones. For the general public, however, there was considerable of interest, notwithstanding the absence of many of the large electric companies, such as the General Electric, Westinghouse, Sprague, Stanley, etc. There were about fifty exhibits, nearly all of which were on the main floor, and the remainder in the gallery.

Among the exhibits of special interest may be mentioned that of the New York Telephone Company, whose spacious booth, in the center of the Garden, contained a section of a central exchange in operation, with connections to every booth in the building and with the outside world. A "theatrephone" installation, with receivers connected with the city theatres, was at the service of visitors without charge, and a number of historical telephone relics attracted considerable attention.

The exhibit of the Street Cleaning Department of the City of New York was interesting. A 30-foot working model was shown of the light refuse crematory and municipal lighting plant recently started in the city, together with a model of the Williamsburg Bridge, which is lighted by the current from it.

The American De Forest Wireless Telegraph Company had on exhibition a ½-kilowatt portable wireless telegraph outfit, and a 2-kilowatt wireless signal equipment similar to that used by the Japanese in the late war. On the roof of the Garden they had erected antennæ to receive messages from ships at sea.

An interesting exhibit was made by the American Telegraphone Company, of New York. The instruments shown received and recorded telephone messages on a steel wire. The magnetic record thus made could be read at any time by running the wire through the transmitter of the machine, and, while of great permanency, could be removed at once by passing the wire between the poles of a small magnet.

The Gray National Telautograph Company, of New York, showed their telautograph in operation, allowing visitors to transmit their writing by means of it and receive the copies thus made.

A miniature electric elevator was exhibited by the Safety Electric Elevator Company, of New York. An electric motor bolted to the elevater and under control of the operator, turned a large drum below the floor of the elevator, and a spiral rib on the face of the drum engaged with two racks on opposite sides of the elevator shaft. The elevator was thus moved up or down according to the direction of rotation of the spiral. Friction is reduced by the use of rollers in the rack, but owing to the low pitch of the spiral rib the elevator will not drop even if the power gives out.

The Electro-Dynamic Company, of Bayonne, N. J., exhibited one of their "interpole" variable-speed motors, driving another similar machine as a generator at speeds from 250 to 1600 revolutions per minute. The motor was also shown overloaded 100 per cent. without sparking, and no sparking occurred when the motor was reversed under overload.

The electric clock system of The Magneta Company, of New York, was well shown. In this system a single master clock electrically controls all the clocks of a building, district, or city. The master clock is driven by weights, and at the end of each minute sends an electric current through the circuit of clocks which moves their hands simultaneously. The electric current is developed inductively in the master clock by the movement of an armature through a magnetic field.

The Wireless Electric Company, of Philadelphia, Pa., exhibited a working model of the Pullen surface-contact system of electric street railways, and also a full-sized working model of an electric locomotive for use in mines.

Electrically driven refrigerating outfits for use in place of ice boxes and for making ice in small quantities for table use, were shown in operation by the Brunswick Refrigerating Company, of New Brunswick, N. J.

The Sarco Company, of New York, exhibited flame arc lamps of German manufacture which produced a golden yellow, red, or white light according to the character of the carbons used.

Experiments with high frequency currents were performed daily by Earle L. Ovington, of the Ovington Manufacturing Company, Boston, Mass., in the Concert Hall of the Garden. Among the experiments on the programme were the following:—Lighting an incandescent lamp using only one wire; passing current through 2 inches of solid glass; sending wireless messages through the human body; tranmission of power without wires; lighting five incan-

descent lamps and melting metal wire with currents passing through the human body; and lighting a vacuum lamp with currents passing through the sensitive membranes of the mouth.

In addition to the displays already mentioned, exhibits were made by The Kinsman Block System Company, of New York; The George L. Mason Company, of New York; The Stow Manufacturing Company, of Binghamton, N. Y.; Holcombe & Company, of New York; The Standard Vitrified Conduit Company, of New York; The Enos Company, of New York; Waterbury & Company, of New York; The Kinsman Electric Railway Supply Company, of New York; The Peerless Electric Company and The Magnet Wire Company, of New York; The Niagara Tachometer & Instrument Company, of Niagara Falls, N. Y.; The Cooper Hewitt Electric Company, of New York; The General Storage Battery Company, of New York; The National Carbon Company, of Cleveland, O.; The Van Dyck-Churchill Company, of New York; The National Meter Company, of New York; The Engineering News Publishing Company, of New York; The International Text Book Company, of Scranton, Pa; The Simplex Electric Heating Company, of Cambridgeport, Mass.; Dossert & Company, of New York; William Green & Company, of New York; The Gold Car Heating & Lighting Company, of New York; The Maloney Electric Company, of St. Louis, Mo.; The American Electric Novelty & Manufacturing Company, of New York; The Clark Electric Manufacturing Company, of New York; The Prometheus Electric Company, of New York; The Clifton Manufacturing Company, of Boston, Mass.; G. M. Gest, of New York; The Chicago Pneumatic Tool Company, of Chicago; Caldwell & Ousterhoudt, of New York; The National Battery Company, of Buffalo, N. Y.; The Tacony Iron Company, of Philadelphia, Pa.; Charles A. Thompson Company, of New York; Charles E. Dressler & Bro., of New York; The "Navalite" Conduit Company, of New York; The Electro-Radiation Company, of Boston, Mass.; Waite & Bartlett Manufacturing Company, of New York; and The Eastern Carbon Works, of Jersey City, N. J.

Electric light fittings and similar articles manufactured electrolytically, were exhibited at a recent electrical show in London.

Book News

Notes on Mechanical Drawing

By Horace P. Fry. Size 6 x 9 inches. 55 pages. 47 illustrations. Published by the author at the University of Pennsylvania, Philadelphia.

The notes contained in this booklet were prepared for the use of students in mechanical engineering at the University of Pennsylvania; hence much of the preliminary instruction given, such as size of sheets, arrangement of views, and the like, is of a purely arbitrary kind. One rule specifies that all drawings are to be inked in with black India ink, which is to be prepared by the student, except where otherwise specified. It is extremely doubtful if the student will meet with such a rule outside of the university. Bottled ink ought to serve for any drawing and save a deal of time.

The various instruments needed are listed, and the usual directions as to thickness of lines, spacing in broken lines, and shade lines are given. Projections in different planes, sections, cross hatching, and the other conventionalities of draughting are also dealt with. Tables of screw threads, bolt heads and nuts, wrought iron pipe, wire gauges, and decimal equivalents complete the book.

Mechanics of Air Machinery

By Julius Weisbach and Professor Gustav Herrmann. Size 6 x 9 inches. 201 pages. Published by the D. Van Nostrand Company. Price, $3.75.

This book contains a translation of that portion of Weisbach's work on "Engineering Mechanics" which relates to the moving of air, and in addition an appendix showing some features of recent American practice in air machinery.

The appendix includes descriptions of the machines illustrated, and gives the changes in air machinery resulting from the introduction of high-speed steam engines and gas engines. The various types of fan blowers that have come into common use during the last ten years are also given attention. This portion of the book should appeal to the designer of air machinery, as the demands made by users are indicated, and some of the devices employed to meet these demands are shown.

High-Tension Power Transmission

Size 6½ x 9½ inches. 457 pages. Published by the McGraw Publishing Company. Price $3.

The matter given in this volume comprises a series of papers and discussions presented at the meetings of the American Institute of Electrical Engineers, under the auspices of the Committee on High-Tension Transmission. Data regarding line construction, insulators, insulator pins, conditions of operation at different voltages and under different climatic conditions, methods of testing insulators, methods employed for voltage regulation, the conditions attendant upon the switching of high-tension circuits, lightning and static disturbances, and the use of grounded protective wires, are here given in compact and convenient forms for reference.

The publication of this matter in book form is by special permission of the American Institute of Electrical Engineers. The data collected by the committee, the discussions on the various subjects relating to high-tension power transmission, and the introductions prepared for the several subjects by members of the Institute prominent in transmission work, as they appear in this book have been taken directly from the Transactions of the Institute, only such changes being made as were necessary for co-ordinating the different parts.

Physics

By Charles Rivorg Mann and George Ransom Twiss. Size 5 x 8 inches. 453 pages. Published by Scott, Foresman & Co. Price $1.25.

This book is an up-to-date "natural philosophy." The work is intended primarily as a text book for high schools, but there is no doubt that it contains much matter that will prove of utility to intelligent mechanics and artisans, and for that matter, to the general reader interested in science. It is written in plain, every-day language, and is illustrated with numerous half-tones of the objects described.

The following outline of a few of the subjects treated will give a fair idea of the wide scope of the book:—Motion, velocity, acceleration, mass and energy; fly-wheels, angular measurement and units; fluids, heat and work, transfer of heat, the steam turbine, the gas engine, the triple-expansion engine; electricity, transmission of power; magnetism, earth's magnetism; wave motion, water waves, velocity of propagation; simple harmonic motion; sound; the musical scale; light, refraction, reflection, colour, velocity of light; wireless telegraphy; electrons.

Among the illustrations are a pile driver at work, a jack screw in action, trains in motion, oarsmen in boat, the steam turbine, dynamos in power plants, etc.

In brief, the book discusses briefly and clearly almost every known branch of applied science, and will be found very useful as a reference book on many subjects.

Distribution of Transmitted Power in Buffalo

By ALTON D. ADAMS

TERMINAL HOUSE OF THE CATARACT POWER & CONDUIT COMPANY. THREE 22,000-VOLT LINES ENTER AT THE WEST END, AND THE 2200-VOLT LINES LEAVE THE BUILDING ALONG THE NORTH WALL, PASSING UNDER THE 22,000-VOLT LINES AND EXTENDING SOUTHWARD ALONG THE ERIE CANAL, SEEN IN THE FOREGROUND, TO MANUFACTURING PLANTS IN NORTH BUFFALO

NIAGARA FALLS power, to the extent of 18,000 KW., is distributed in Buffalo for the operation of more than 5000 arc lamps, nearly 150,000 incandescent lamps, stationary motors of about 23,000-H. P. capacity, and all the electric cars in the city. This power comes to Buffalo over three 22,000-volt, 25-cycle, three-phase circuits on two-pole lines, which enter a terminal house in the suburbs of the city, about 23 miles from Niagara Falls.

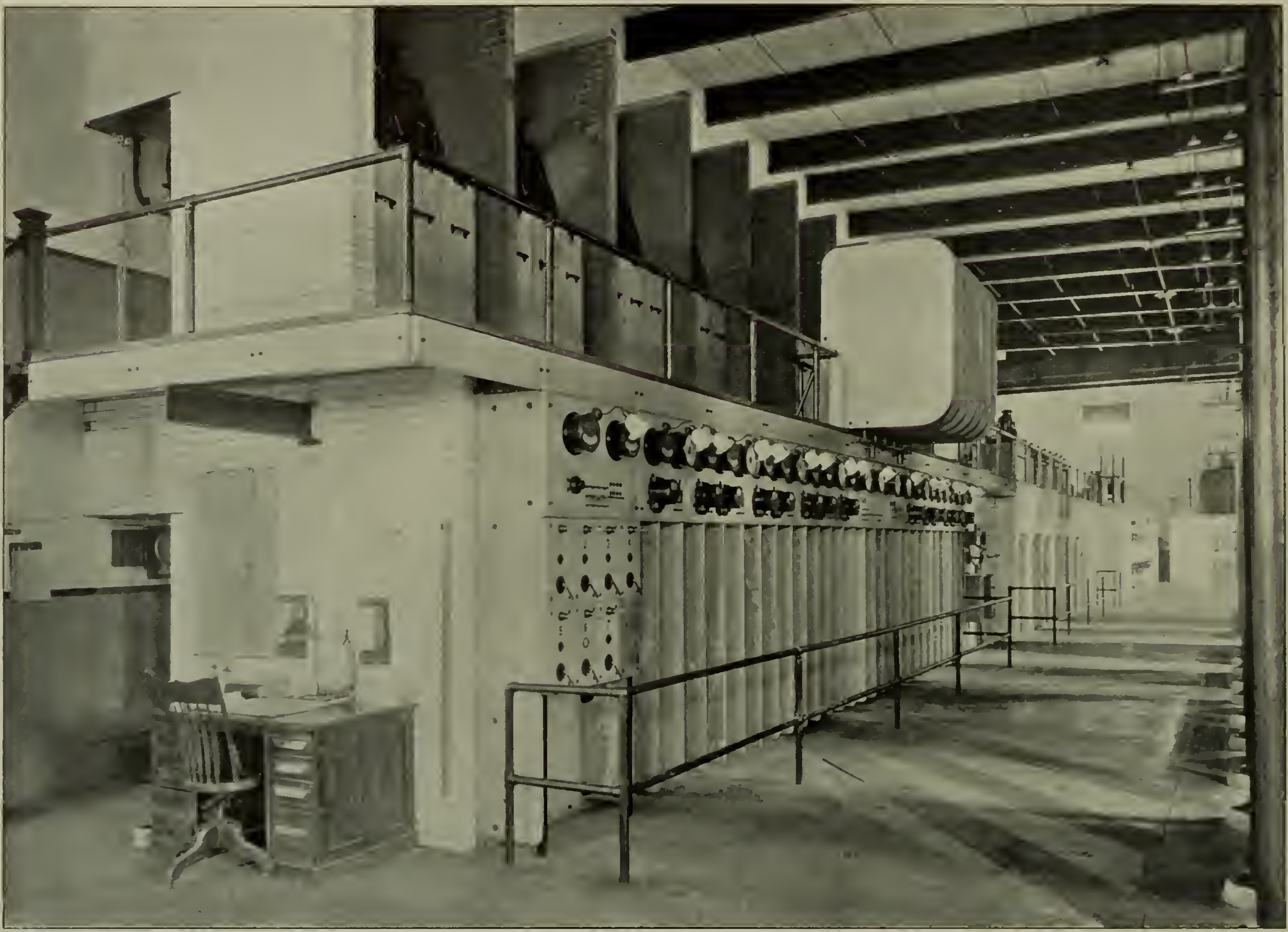
At this terminal house the voltage of the current is reduced to 11,000, and it is then carried by underground cables to eight sub-stations in different parts of the city, where it is transformed and converted to 2200 volts, 25 cycles, three-phase, to 2200 volts, 60 cycles, two-phase, to 550, 500, 250 and 125 volts direct current, and to constant 6.6-ampere current for arc lighting. The 550-volt current is used by the railway, the 500-volt for stationary motors, and the 250 and 125-volt current for commercial lighting on a three-wire system.

Current of 60 cycles per second, two-phase, is devoted to arc and incandescent lighting for private consumers, and 2200-volt, 25-cycle, three-phase current operates induction motors and incandescent lamps.

At the terminal house near the foot of Ontario Street, on the Erie Canal, the nine conductors of the three 22,000-volt circuits enter a brick end wall through nine porcelain tubes set into a 1-inch pine board. Each tube is 1 foot long, is inclined at an angle of 30 degrees with the horizontal, and all are protected by metal hoods on the face of the wall. Within the terminal station, the three transmission circuits, after connecting with lightning arresters, pass through high-tension switches to the transformers that receive all the electric energy distributed in Buffalo.

These transformers are nine in number, and are connected in three groups, one group for each 22,000-volt, three-phase circuit. Each transformer is rated at 2250 KW., the three of each group are connected in delta, and their transforming ratio is two to one, so that the sec-

THE EAST END OF THE TERMINAL HOUSE, SHOWING SELECTOR SWITCHES AND 22,000-VOLT OIL SWITCHES FOR TRANSFORMERS



TERMINAL HOUSE OF THE CATARACT POWER & CONDUIT COMPANY, SHOWING THE 11,000-VOLT DISTRIBUTION BOARD AND THE OIL SWITCHES ON THE UNDERGROUND FEEDERS. THE CONTROLLERS FOR THE SWITCHES ARE ON THE FIRST PANEL OF THE BOARD

ondary coils deliver 11,000-volt, three-phase current. Secondary terminals from these transformers go to a switchboard with two sets of bus-bars, to oil switches, by which they can be connected to either set, and to indicating and integrating wattmeters.

THREE BANKS OF 2250-KW. TRANSFORMERS IN THE TERMINAL HOUSE

As each of the aforementioned transformers is rated at 2250 KW., their combined capacity is 20,250 KW., or about 10 per cent. greater than the December load of 1904. Each of these transformers working between 22,000 and 11,000 volts is oil-insulated and cooled with water from the Erie Canal.

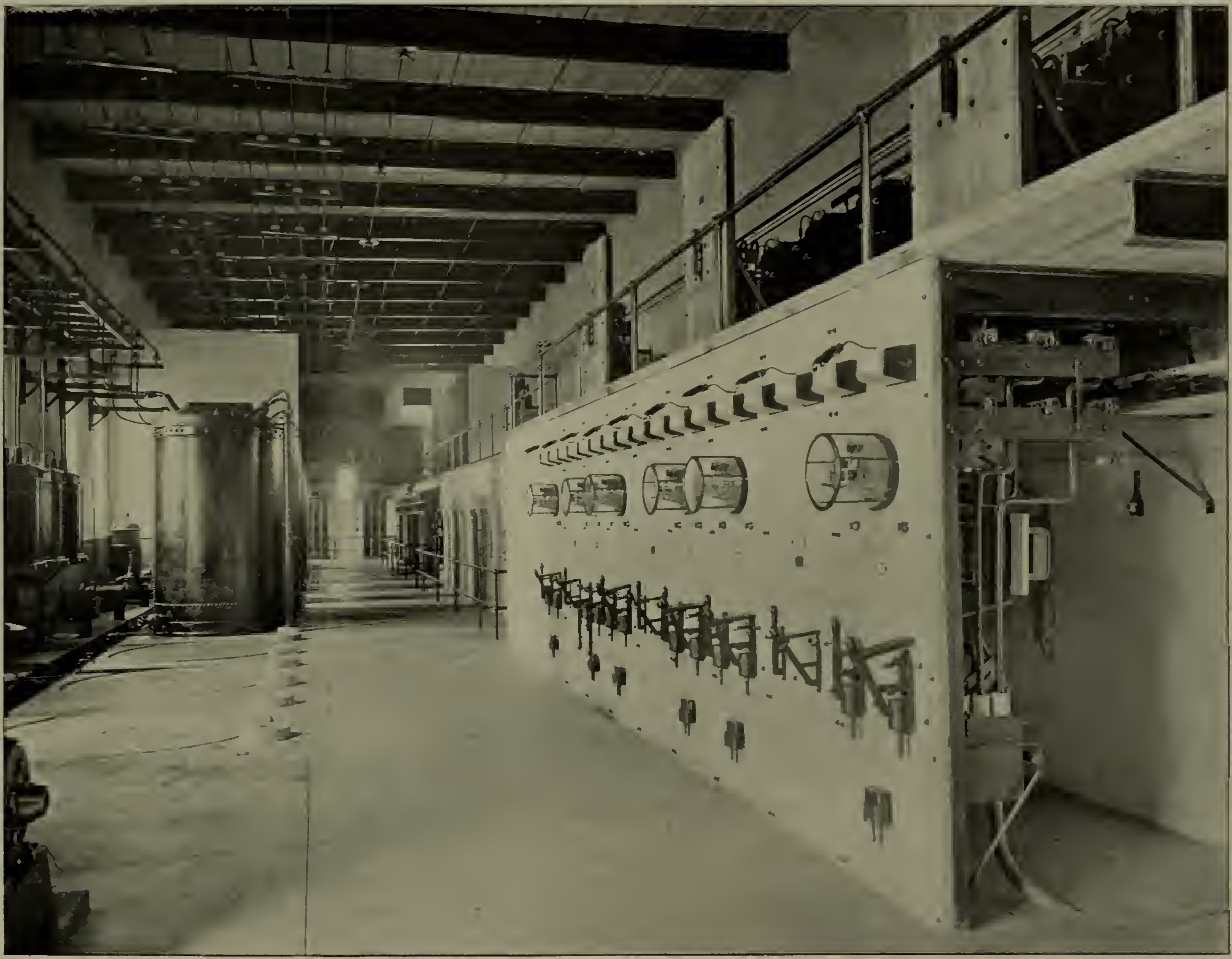
Besides the nine transformers already mentioned, the terminal station contains also nine other transformers, each rated at 250 KW., with 11,000 volts at the primary, and 2200 volts at the secondary terminals. These 250-KW. transformers are of the air-blast type, and their combined capacity is 2250 KW. Current delivered by these transformers, at 2200 volts, 25 cycles, three-phase, is distributed by overhead circuits to manufacturing plants in North Buffalo, and much the greater part of it is used for the operation of induction motors, though it also does the necessary lighting.

From the terminal station, the 11,000-volt, 25-cycle, three-phase current is carried through underground cables to five sub-stations of the International Railway Company, and to three sub-stations of the Cataract Power & Conduit Company. The most distant of these sub-stations, that of the railway at Seneca and Elk Streets, is 8½ miles from the terminal station, and about 31½ miles from Niagara Falls.

with 11,000 volts primary, and 2200 volts secondary, 25-cycle, and three-phase. The combined capacity of transformers in this sub-station is thus 5100 KW. and their output is distributed mainly by overhead circuits to manufacturing and industrial plants, where it is largely devoted to the operation of motors.

At Babcock and Hanna Streets, the sub-station is several miles distant from the business center of the

current at two secondary voltages. One group of twelve transformers, rated at 250 KW. each, operates at about 11,000 volts primary, and 2200 volts secondary, and the capacity of this group is thus 3000 KW. The other group contains 21 transformers, each rated at 250 KW., and operating between 11,000 volts primary and 352 volts secondary. For this group the total capacity is 5250 KW., giving the sub-station a trans-



THE 2200-VOLT FEEDER BOARD IN THE TERMINAL HOUSE. THE VIEW IS TOWARD THE WEST END WHERE THE 2200-VOLT LINES ENTER

Of the three sub-stations belonging to the Cataract Power & Conduit Company, one is on Ohio Street and Love Alley, another is on Wilkeson Street, ½ mile from the business center of the city, and the third is at Hanna and Babcock Streets. All these sub-stations are buildings with brick walls and concrete floors, like the terminal house, and are only one story high.

In the sub-station at Ohio Street and Love Alley the equipment includes six oil-insulated, water-cooled transformers, each rated at 850 KW.

city, and like that on Ohio Street, its output is distributed mainly by overhead lines for industrial power purposes. In the Babcock Street sub-station, there are nine transformers of the air-blast type, each rated at 250 KW., with 11,000 volts primary, and 2200 volts secondary, 25-cycle, three-phase. This gives the sub-station a capacity of 2250 KW.

The Wilkeson Street sub-station supplies the energy for the great bulk of downtown lighting in Buffalo, as well as that for a large motor load, and its transformers deliver

forming capacity of 8250 KW. All these transformers are cooled by air blast, and deliver three-phase, 25-cycle current.

Current from the transformers that have a secondary voltage of 2200 at the Wilkeson Street sub-station is distributed for both motive power and lighting. All the current from the transformers having a secondary voltage of 352 at this sub-station, goes into the adjoining sub-station of the Buffalo General Electric Company, where it is used to operate motor generators and rotary con-

verters. From the foregoing it may be noted that the total capacity of transformers delivering 2200-volt, 25-cycle, three-phase current in the terminal station and at the three sub-stations of the Cataract Power & Conduit Company is 12,600 KW., used partly for lighting, but much more for power. On the other hand, the output of the transformers rated at 5250 KW. and 352 volts, in the Wilkeson Street sub-station, is devoted in great part to lighting, and to a minor extent to power.

At the Wilkeson Street sub-station of the Buffalo General Electric Company, four distinct systems of lighting service and one of power service are provided. For the operation of motors the two-wire system with direct current at about 500 volts is employed, and this current is obtained from rotary converters that receive the 352-volt, three-phase, 25-cycle current from the transformers in the adjoining sub-station.

It was the necessity for about 352 volts at the collecting rings of the rotary converters, and the desire for a uniform secondary voltage at the transformers supplying the apparatus in the sub-station of the Buffalo General Electric Company, that led to the adoption of this voltage for the secondary coils of the aforenamed 21 transformers of 5250 KW. total capacity. As all the motor-generators operated by these transformers are of the revolving-magnet type, with fired armature windings, the rather large currents incident to the voltage of 352 presented no serious objection.

For series arc lighting, both public and commercial, 6.6-ampere arc dynamos are operated by direct-coupled, 352-volt, 25-cycle, three-phase, synchronous motors. Distribution for commercial arc and incandescent lighting is carried out with two-phase, 60-cycle current of 2200 volts from generators direct coupled to synchronous motors of the type just named. Synchronous and induction motors operating at 352 volts also drive 150-volt, direct-current generators that feed the three-wire system. To these classes of distribution should be added that of 2200-volt, 25-cycle current for incandescent lighting, some of which is now used by the Buffalo General Electric Company as it comes from the transformers of the Cataract Power & Conduit Company.

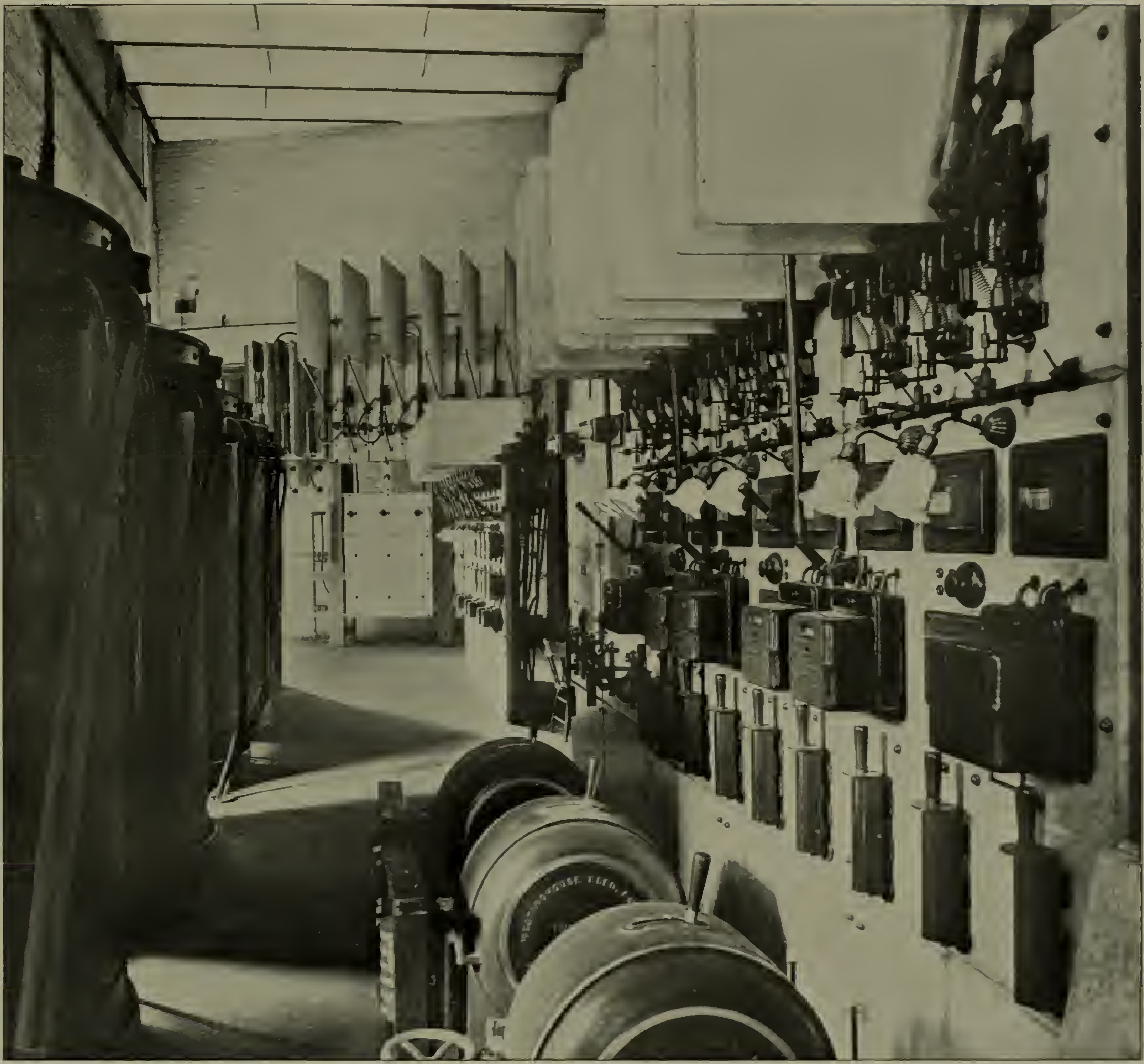
For the series arc lighting there are 32 Brush arc dynamos, rated at 6.6 amperes and 8000 volts each, and driven by thirteen 200-H. P. synchronous motors. Seven of these have two arc dynamos direct connected to the shaft of each, and the other six motors have three of the arc dynamos direct connected to each shaft. Each of four 565-H. P., 352-volt, synchronous motors is direct connected to a 400-KW., 2200-volt, 60-cycle, two-phase generator. One 1200-H. P., 25-cycle, three-phase induction motor is direct coupled to a pair of 400-KW., 150-volt, direct-current generators.

Another pair of the same type of generators, but of 200-KW. capacity each, is direct driven by a 565-H. P. synchronous motor. A 200-H. P. synchronous motor is coupled to a 55-volt, 1091-ampere booster dynamo, and two 30-H. P. induction motors are connected respectively to an equal number of 20-KW., 125-volt exciting dynamos. From the above it may be seen that the total capacity of motors and rotary converters supplied with current at 352 volts from the transformers rated at 5250 KW. is about 7950 H. P.

Besides this, there are two rotary converters rated at 100 KW. and 125 volts that were intended for use on the three-wire system, but it was found that the motor generators gave better results as to constant voltage. In the 32-arc dynamos, there is a capacity for about 3200 enclosed arc lamps. The 2200-volt, 60-cycle generators have a combined rating of 1600 KW. In the four direct-current, 150-volt generators devoted to the three-wire system there is a capacity of 1200 KW. For the 500-volt motor circuit the three rotary converters have a rating of 1000 KW.

With the increasing load on the three-wire system, an addition to its generator capacity was found necessary some months ago. If this addition had been made at the Wilkeson Street sub-station, in the form of

STATION NO. 2, SHOWING ALSO THE 2200-VOLT FEEDERS LEAVING THE TERMINAL POLE



THE 2200-VOLT FEEDER BOARD, THE OLD PRIMARY 11,000-VOLT SWITCHBOARD, AND THE TRANSFORMERS IN STATION NO. 2

either motor generators or rotary converters, it would have been necessary to lay some heavy underground feeders from that point into the business district.

To avoid the investment in such feeders, it was decided to locate the new generating apparatus in underground sub-stations close to the three-wire mains, near the points of heaviest load. Suitable locations for two such sub-stations of equal capacity were found beneath the sidewalk, and each was constructed with concrete walls and floors.

Each of these underground sub-stations contains three air-blast transformers of 186-KW. capacity each, a motor-driven blower, a 500-KW. rotary converter, two switchboards with oil and selector switches, and a potential regulator. With all this apparatus, the 23 by 24-foot floor area of the sub-station is reduced only 11 feet by 9 feet 4 inches, inside. The concrete walls have a uniform thickness of 18 inches.

Underground cables bring 11,000-volt, 25-cycle, three-phase current to each of these two sub-stations, and the transformers lower this voltage to that necessary for the rotary converters which deliver direct current at 250 volts for the three-wire system. Current at this voltage is supplied to the two outside wires of the system, and the regulation for unequal loads between the outside wires and the neutral is accomplished at the Wilkeson Street sub-station, where the 150-volt motor generators are located. It may be noted that the converters, which gave unsatisfactory results at the sub-station just named, were connected between each outside wire and the neutral of the three-wire system, while the converters in the underground sub-stations are connected only to the outside wires. A storage battery, of 6000-ampere capacity, is also connected to this three-wire system.

In 1904, the Cataract Power & Conduit Company, which distributes only three-phase, 25-cycle current, was operating 18,642 incandescent lamps, and motors of 18,124 aggregate horse-power for private consumers. At the same time, the Buffalo General Electric Company had

STATION NO. 4, SHOWING THE 2200-VOLT LINES LEAVING THE BUILDING

connected to the lines from the Wilkeson Street sub-station 3108 series enclosed arc lamps, 596 direct-current and 1415 alternating-current arcs on constant-pressure circuits, 30,008 incandescent lamps on the three-wire system, 88,641 incandescent lamps fed by the 2200-volt circuits, and motors with a total rating of 3085 H. P., mostly on the 500-volt, direct-current service.

On September 2, 1905, the maximum power delivered by the 2200-volt, two-phase, 60-cycle lines of the Buffalo General Electric Company was 2100 KW. From the 250-volt Edison three-wire system on the same date the greatest output was 1320 KW. The 2200-volt, three-phase, 25-cycle lines of this company had a load of 520 KW. on the day named.

This brings up one of the most interesting features connected with the distribution of Niagara power in Buffalo, that is, the use of 25-cycle current for incandescent lighting. About 255 service transformers are connected to the 2200-volt, 25-cycle lines of the Buffalo General Electric Company for lighting purposes, and the combined capacity of these transformers is 18,096 lamps of 16 candle-power each. Lamps operated with the 25-cycle current are in use for residence lighting and in many public places. Among these latter may be named the following, with the number of lamps in each:—

Buffalo Club	678
Grosvenor Library	246
Lafayette High School	1,647
Genesee Hotel	1,500
Athletic Park	4,000
Buffalo Country Club	150
Park Club	200
74th Regiment Armory	1,500
Albright Art Gallery	297
Total	10,218

In the Buffalo Club, 82 of the lamps are of 32 candle-power, and 167 lamps are of 8 candle-power each, all the others being 16 candle-power lamps. The Albright Art Gallery has also 265 Nernst lamps operated with the 25-cycle current. Besides the lamps using 25-cycle current from the lines of the Buffalo General Electric Company, the Cataract Power & Conduit Company is operating thousands of such lamps in factories where the same current is supplied for motive power. Particular interest attaches to this extensive use of 25-cycle current for incandescent lighting in Buffalo, because of the opinion held by many engineers that satisfactory service cannot be given in this way.

TRANSFORMERS AND 11,000-2200-VOLT SWITCHBOARD IN STATION NO. 4. THE SERIES AND POTENTIAL TRANSFORMERS FOR THE INSTRUMENTS ARE MOUNTED ON THE WALL

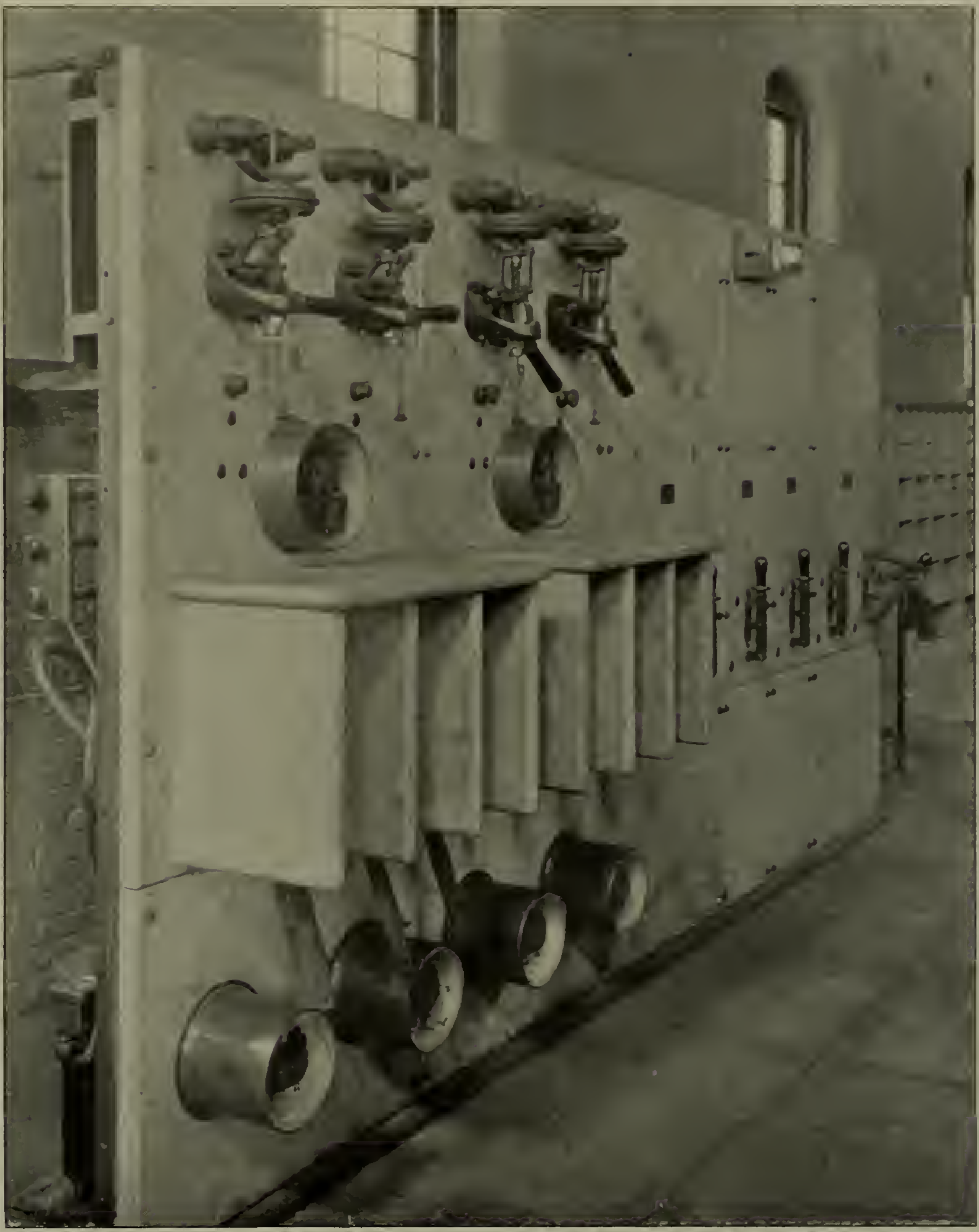
A Society of Illuminating Engineers

THE rapid growth of interest in artificial illumination, and the increasing importance of its scientific treatment are very well illustrated among other things by recent preliminary arrangements made at New York for the formation of a "Society of Illuminating Engineers." These took the shape of an informal dinner attended by a number of electrical engineers and architects a few weeks ago, at which the formation of such a society was made the topic of discussion.

A committee was appointed to take under consideration a name for the proposed society, the drafting of a constitution and by-laws, the fixing of dues and other details, and a report is to be submitted at another meeting this month, when, it is ex-

pected, the society will be formally organized.

The first meeting was called in a circular signed by Messrs. L. B. Marks, E. L. Elliott, and V. R. Lansingh. Among those in attendance were representatives of the New York Edison Company, the General Electric Company, the Electrical Testing Laboratories, the Edison Lamp Works, and several prominent firms of architects and makers of electric light fixtures.



THE 11,000-VOLT PRIMARY SWITCHBOARD IN NIAGARA STATION NO. 4, BUFFALO

Electrification by the Pennsylvania Railroad

THE Pennsylvania Railroad Company has recently decided to electrify a part of its system, comprising about 64 miles of steam road lying between Camden and Atlantic City, N. J., being a part of the West Jersey and Seashore branch. It is proposed to utilize the Cape May line of this system from Camden as far as Newfield, this line being double-tracked with 100-pound rails, and to build an additional track from Newfield to Atlantic City, making the lines double track throughout.

Over this roadbed an express service will be established. The initial installation will provide for a three-car train every fifteen minutes between Camden and Atlantic City, making the 64 miles in eighty minutes without stops. The maximum speed of the cars will be between 55 and 60 miles per hour.

In addition to this through service to Atlantic City, a half-hour schedule is planned, consisting of two-car trains between Camden and Millville, 40 miles, and ten minute service of single cars between Camden and Woodbury, 8½ miles. Full service will call for 58 cars in operation, each equipped with two 200-H. P., direct-current General Electric motors. These motors will be similar to those now being manufactured by the General Electric Company for the equipments of the New York terminal of the New York Central & Hudson River Railroad. The motors will be controlled by the Sprague-General Electric automatic multiple unit system.

Current will be furnished to the cars by the third-rail system, except on the sections between Camden and Woodbury, and Newfield and Millville, where the cars will obtain the necessary current by an overhead trolley. The speed on these sections is less than on the main line.

The power house will be located at Camden. Power for the operation of the cars will be furnished by three 2000-KW. General Electric-Curtis turbo-generators of the three-phase alternating-current type, having a frequency of 25 cycles. From this power house, transmission lines will be run to six sub-stations between Camden and Atlantic City, and to a seventh sub-station at Millville to supply that section of the road lying between Millville and Newfield.

The transmitting potential will be 33,000 volts. At the sub-stations a total capacity of 11,000 KW. in rotary converters will be provided, delivering direct current to the third rail at 650 volts. The individual units will be of the standard General Electric type and will have a capacity of 750 KW. They will be started from the alternating-current end by means of taps on the step-down transformers.

The contract calls for the completion of this road by July 1, 1906, in order to take care of the heavy summer traffic. The total amount of money involved is about $3,000,000. The electrical equipment will be furnished by the General Electric Company, of Schenectady, N. Y.

According to Russian statistics, it was not until about 1825 that platinum was considered of any great value. On its discovery over a century ago it was regarded as of less value than silver. The Russian Government tried to use the metal for coins, and between 1825 and 1848 coins of 3, 6 and 12 roubles were struck off in platinum in St. Petersburg, but the experiment was not repeated. In 1843 the output of Russian platinum amounted to 6613 pounds; in 1848 the output fell to only 110 pounds, and since that year the output has risen gradually.

The Electric Smelting of Zinc

By OLIVER W. BROWN and WILLIAM F. OESTERLE

A Paper Read at the Recent Eighth General Meeting of the American Electrochemical Society, at Bethlehem, Pa.

MUCH attention has been given to the reduction of zinc ores, by electrical and other means, during the last few years. This is not surprising when one realizes that the ordinary zinc smelting process is the most wasteful metallurgical operation used industrially at the present time. The fuel consumption, the cost of repairs and the loss of zinc are very large. The average life of the retorts used in many works is only forty to fifty days, while the loss of zinc is seldom less than 10 per cent., and sometimes more than 25 per cent. of the zinc in the ore.

Another great drawback to the process is that the retorts will hold only about 65 pounds of ore. The zinc retorts most commonly used are fire-clay tubes about 4 feet 2 inches long, 8 inches in diameter and 1¼ inches thick. They are made closed at one end, and into the mouth of each retort is fitted a fire-clay condenser. They are supported at each end by projections from the walls of the furnace, and are placed in horizontal rows in the furnace in such a manner that the flames entirely surround them while they are being heated.

The most important zinc ore is the sulphide, and this ore, before distilling in the retorts, must be roasted for about 48 hours in a separate roasting furnace to convert it into an impure oxide. One or 2 per cent. of the zinc in the ore is generally lost by volatilization during the roasting process, and the roasted ore still contains 1 to 2 per cent. of sulphur, which keeps back an equivalent amount of zinc in the retorts.

The roasted zinc ore is mixed with coal and coke, and charged into the previously heated retorts. The retorts and contents are then heated for about 20 hours, up to a white heat. The zinc oxide is reduced to metal by the white-hot carbon, or carbon monoxide, and distills down into the fire-clay condensers, where it condenses, in part as a fine powder and partly as fused metal.

The reduction temperature of zinc oxide, as determined by W. McA. Johnson, is about 1033 degrees C.; however, all of the zinc will not be expelled from the retort below a white heat. The molten metal is generally drawn from the condensers into a ladle three times during the distillation. Some of the zinc vapour passes through the pores and cracks of the retorts and is lost, while the fire-clay retorts themselves often absorb as high as 15 per cent. of their own weight of metallic zinc. A part of the metal remains in the charge after distillation, because the retorts cannot be heated to the temperature required to expell all of the zinc without cracking or melting them. The charge from which the zinc has been distilled generally contains at least 2½ per cent. of metallic zinc, and often much more than this amount. Only pure ores can be used, as the iron and calcium in low-grade ores form a very corrosive fusible slag, which corrodes through the retorts at a comparatively low temperature. The retorts cannot be made much longer or wider than those used at present and still hold up their own weight and that of the charge, when heated to a white heat.

As crude and wasteful as this method is, it is employed to produce nearly all of the zinc used at the present time. The enormous amount of heat wasted during the smelting of zinc ores, the loss of zinc, and the cost of operating this process, has caused the problem of the extraction of zinc from its ores to be a favourite field of reasearch with many investigators.

Electrochemists have attacked this problem along three different lines, namely, the conversion of the zinc in the ore into a salt soluble in water and the subsequent electrolytic precipitation of the metal from an aqueous solution; conversion of the zinc to chloride and the electrolytic separation of the metal from the anhydrous fused salt, and the electric smelting of zinc ores.

A special endeavour has been made to develop electrical processes by which zinc can be economically extracted from complex and low-grade ores, which cannot be smelted in the ordinary manner. Of all the processes which have been suggested, involving the electrolytic precipitation of zinc from aqueous solution, that developed by Hoepfner is the only one that appears to have approached a commercial success. Brunner, Mond & Co., during the last few years, have turned out a very pure electrolytic zinc from their works at Wilmington, near Chester, England. Little is known concerning the details of their process except that it is based on the Hoepfner patents.

The Hoepfner process was also used in a works located at Fuhrfort, Germany, from 1895 to 1897, but it has been discontinued. In this works metallic zinc and chloride were produced by the electrolysis of a solution of zinc chloride. The chlorine was converted into bleaching powder. It seems that the success of this process was not great. The iarge amount of powder required to precipitate zinc from aqueous solutions will always be one of the greatest hindrances to any process of this kind.

Many electrochemists have believed that the treatment of low-grade zinc ores could be successfully accomplished by a process in which the zinc is separated by the electrolysis of some anhydrous fused salt of zinc, like the chloride. Richard Lorenz, Borchers, Swinburne, Ashcroft and others have endeavoured to develop processes for zinc extraction depending on the electrolysis of fused salts. In this field the Swinburne-Ashcroft process seems to be the best and to have a very bright future.

Few trials in the electric smelting of zinc ores were made until within the last few years, although the Cowles Bros., of Cleveland, carried out experiments on the smelting of roasted zinc ores by electrical heating as early as 1882. These early experiments did not lead to a commercial process.

C. Casorette and F. Berboni, of Milan, Italy, have invented a furnace for smelting zinc ores which contains two muffles, the second being heated by electrical means.

An electric arc furnace for smelting zinc ores has recently been invented by Dr. C. F. T. de Laval. In

his furnace the pulverized zinc ore, mixed with the proper reducing and fluxing materials, is fed into the top of an electric furnace in such a manner that in descending it presents an inclined surface to the heat radiated from an arc. The zinc vapours are conducted to a condenser, while the gangue as it descends into the lower part of the furnace is fused and is drawn from the furnace in the molten condition. It is claimed that in smelting 40 per cent. zinc ore in a 100-KW. furnace, nearly 5 kilogrammes of metallic zinc are produced per kilowatt-day.

The Cowles Bros., Casorette and Berboni, and de Lavel have tried to design electric furnaces in which roasted zinc ores could be smelted in the ordinary manner, except that the heat be generated by electrical means.

A. Dorsemagen, of Wesel, Germany, has worked out a process in which he smelts a zinc ore in an electric furnace with the simultaneous production of a valuable by-product. His process is designed for the treatment of zinc silicate ores. He mixes a zinc silicate ore with carbon in proportions indicated by the reaction $Zn_2SiO_4 + 5C = 2Zn + SiC + 4CO$, and heats the charge in an electric furnace. The zinc distills out and is condensed in the usual manner, while the silicon of the ore combines with carbon, forming carborundum. The inventor claims the advantages of supplying the heat required for the reduction of the zinc ore and the formation of silicon carbine at the same time, thus reducing the loss of heat due to radiation and the amount of heat required to previously heat the reacting materials.

If a process were devised to electrically smelt unroasted zinc sulphide ore, the advantages of electrically heating the charge could be realized, while at the same time all the cost of roasting the ore could be saved. After experimenting for about two years on the extraction of zinc from its ores by electrolysis of fused salts and of aqueous solutions, the writers attempted to find such a process. Interesting results were obtained from a process based on the electrical smelting of charges of unroasted zinc blende, lime and carbon, mixed in proportions corresponding to the following equations:—

$$\text{(a)}\quad 2ZnS + 2CaO + 7C = 2Zn + 2CaC_2 + CS_2 + 2CO,$$
$$\text{(b)}\quad 2ZnS + CaO + 4C = 2Zn + CaC_2 + CS_2 + CO.$$

A process patented by Paul Dankwart, of Deadwood, S. D., is similar in some respects to that employed by the writers. Dankwart smelts mixed sulphide ores containing zinc, with lime, coke and sodium sulphate. He mixes the different materials in such proportions that the sulphur of the ore is converted into alkaline and alkaline earth sulphides, while the zinc is liberated as vapour and is condensed in the usual manner. Dankwart's process is very similar to that of Kirkpatrick-Picard, of London, except that Dankwart adds sodium sulphate to the charge of sulphide ore, lime and carbon, used by Kirkpatrick-Picard, and also carries out his process in an electric furnace.

Kirkpatrick-Picard's process is represented by the following reactions:—

$$ZnS + CaO + C = Zn + CaS + CO$$
$$PbS + CaO + C = Pb + CaS + CO$$
$$4ZnS + 2Fe_2O_3 + 6C = 4Zn + 4FeS + 6CO$$
$$4PbS + 2Fe_2O_3 + 6C = 4Pb + 4FeS + 6CO.$$

He forms the mixture into briquets before the distillation.

The writers first tried the reduction of a charge containing equal molecular weights of zinc blende (59.6 per cent. zinc in ore) lime and carbon (coke) in an enclosed electric resistance furnace lined with fire-brick. This is the same charge as that used by Kirkpatrick-Picard. When this charge was heated in the electric furnace the ore was readily reduced, the metallic zinc distilled out and a portion of it condensed in an iron tube which served as a condenser. The material remaining in the furnace after the distillation, consisting of impure fused calcium sulphide, contained only 0.13 per cent. of metallic zinc.

A study was next made of the electric reduction of charges of zinc blende, lime and carbon (coal or coke), mixed in proportions corresponding to the equations (a) and (b) previously given.

When a charge containing 194 grams of zinc blende (59.6 per cent. zinc), 112 grams of lime, and 84 grams of coke was heated in an enclosed fire-brick-lined electric resistance furnace, with a current of 50 amperes at 30 volts for two hours, zinc distilled and condensed, and the impure carbide remaining in the furnace contained only 0.036 per cent. of metallic zinc and 2.89 per cent. of sulphur. The other impurities in the carbide naturally depend on the purity of the ore treated.

When working with the very small furnace required to smelt charges containing only 194 grams of ore, it was not deemed desirable to endeavour to condense the largest possible proportion of the distilled zinc in a solid metallic form. As experience has shown, the difficulties in condensing the zinc as liquid metal, instead of zinc dust, disappear as the size of the furnace is increased. The analyses of gases coming from the furnace during the operation, of the materials in the furnace after smelting, etc., show that the changes which take place in the smelting are probably best represented by equations (a) and (b).

Some additional experiments which were carried out during 1903 and 1904 by one of the writers (O. W. Brown) on the reduction of zinc blende, furnished the following results:—

When the following charge,—3.98 kilogram zinc blende (containing 58.0 per cent. of zinc), 2.24 kilogram lime (containing 38.2 per cent. of magnesia), 0.84 kilogram of carbon (equal weights of coal and coke), was smelted in an enclosed electric resistance furnace, the material remaining in the furnace after the distillation contained only 0.10 per cent. of metallic zinc. This experiment shows that even when a lime very high in magnesia is used, practically all of the zinc is reduced and distills out of the furnace. However, it is hardly necessary to remark that good calcium carbide cannot be made when a lime containing 38 per cent. of magnesia is used.

The internal dimensions of the furnace in this experiment were:—Length, 12.5 inches; depth, 8.5 inches, and width, 4.5 inches. The inner walls and bottom of the furnace were of magnesia brick. A layer of dry lime was placed on the outside of the magnesia brick, then a layer of fire-brick, followed by another layer of lime, and finally the whole was encased in a sheet-iron jacket. A round Acheson graphite electrode, 2 inches in diameter, entered the furnace at each end. These electrodes were fastened firmly into plates of Acheson graphite 0.5 inch thick, which were placed vertically at each end of the furnace, and reached from the bottom to within 1.5 inches of the top. In order that the furnace should be gas tight, the portions of the graphite electrodes which passed through the walls of the furnace were packed in powdered magnesia brick.

The materials comprising the charge were passed through a 20-mesh sieve and thoroughly mixed, before placing in the furnace. Connection between the two end electrodes was made by two cores of broken carbons (broken to pieces about 0.5 to 1 inch), which were imbedded in the charge. The

lower core of granular carbon was placed 2 inches from the bottom of the furnace, while the second core was about 4 inches above the lower core.

The charge was filled into the furnace to within 1.5 inches of the roof, and was covered with a layer of broken pieces of coke. A carbon tube, 0.5 inch internal diameter and 12 inches long, penetrated the side wall of the furnace, about 2 inches from one end and 2 inches from the top. The tube passed nearly horizontally through the walls of the furnace, the outer end being about 0.5 inch lower than the inner. On the outer end of this carbon tube was fastened a short piece of 1.5-inch iron pipe, which was surrounded with asbestos, and served as a condenser for the zinc. The outer end of the pipe was nearly closed with fire-clay. At intervals during the distillation of the zinc the fire-clay plug was removed and the melted zinc, which had condensed, was allowed to flow out.

The furnace was closed at the top by an Acheson graphite plate, 0.5 inch thick. A layer of lime was placed over the graphite plate, and on this were placed three layers of fire-brick. When the furnace was sealed with dry powdered lime in this manner it was quite tight, and very little gas escaped except through the condenser. A current of about 172 amperes and 68 volts was passed through the furnace for 6 hours and 40 minutes. Zinc vapours had stopped coming from the furnace when the current was broken. After the furnace was allowed to cool and the cover removed, it was found that the charge was a loose porous mass, which could nearly all be removed with the hands. The temperature had not been sufficient to fuse the charge, although all but 0.1 per cent. of the zinc was expelled from the furnace.

In order to gain some idea of the temperature required to reduce and distill the zinc from various charges, and also the relative value of various charges, four different mixtures were made up and heated in a hot coke fire in a wind furnace.

The materials in each charge were pulverized to pass a 20-mesh sieve and were well mixed. The blende used contained 58.6 per cent. of metallic zinc. The charges were as follows:—

No. 1 contained zinc blende, 97; lime 28, and coke, 24 grams, and corresponded to the equation,

$$2ZnS + CaO + 4C = 2Zn + CaC_2 + CS_2 + CO.$$

No. 2 contained zinc blende, 97; lime 56, and coke, 42 grams, and corresponded to the equation,

$$2Zns + 2CaO + 7C = 2Zn + 2Cac_2 + CS_2 + 2CO.$$

No 3 contained zinc blende, 97; lime 56, and coke 12 grams, and corresponded to the equation,

$$ZnS + CaO + C = Zn + CaS + CO.$$

No. 4 contained zinc blende, 97; silica 120, and coke, 24 grams, and corresponded to the equation,

$$2ZnS + SiO_2 + 4C = 2Zn + SiC + 2CO + CS_2.$$

The four charges were placed in separate assay crucibles, loosely covered, and placed in a hot coke fire. Charges 1, 2 and 3 were heated 2¾ hours, while charge No. 4 was heated 2 1-16 hours. A zinc flame burned from the mouths of crucibles 1, 2 and 3 while they were being heated, but no zinc flame was given off from the crucible containing charge No. 4, indicating that no reduction took place in No. 4.

An analysis of charges 1, 2 and 3, after heating, showed that about 55 per cent. of the zinc had been reduced and volatilized in each case. A practically complete reduction and volatilization of the zinc took place when either charge 1, 2 or 3 was heated in an enclosed electric furnace with a current of 50 amperes and 30 volts for 2 hours or less. Only 5 per cent. of the zinc in charge No. 4 was lost during the heating. This loss was probably due to mechanical loss in removing the ignited charge from the crucible after firing.

A charge made up in the same proportions as in No. 4, but containing zinc blende, 194; silica 260, and coke, 48 grams, was heated in an enclosed electric resistance furnace for 1 hour, with a current of 120 amperes and 50 volts. Only a very small amount of metallic zinc (about 1 gram) was found in the condenser, and an analysis of the powder which collected in the condenser showed that it contained only about 4 per cent. more metallic zinc than the charge which was placed in the furnace. The material remaining in the furnace after heating contained 3.98 per cent. of metallic zinc.

These data show that zinc sulphide is not reduced to metal when mixed with silica and carbon and heated to a very high temperature. The temperature attained in this experiment was high enough to volatilize most of the charge out of the furnace, yet the zinc ore was not reduced to metal.

Attention has often been called to the fact that processes requiring widely different conditions cannot be successfully carried on together. This is probably very true of the production of zinc and calcium carbide. The conditions required for the reduction of zinc and the production of calcium carbide are so different that there is little chance for their simultaneous economic production. Even if many of the drawbacks could be overcome, the production of a sulphur-free carbide from a charge of zinc sulphide, lime and coke, is most probably impossible. Also, if calcium carbide is to be made as a by-product, only the purest zinc sulphide could be smelted, as all of the impurities in the ore would contaminate the carbide. However, a method of smelting high-grade zinc ores is not needed so much as a process which will economically obtain the zinc from ores high in iron, etc.

Another disadvantage in the production of zinc and carbide in the same operation is that the sulphur cannot be recovered in a suitable condition, as the greater portion of any carbon disulphide which may be formed in the reduction is burned to sulphur dioxide, which escapes from the furnace in a highly diluted form.

Two very promising lines of investigation are open to those who wish to find an economical electric method of smelting zinc ores. Roasted zinc ores may be smelted in the electric furnace, with coal or coke, and just enough other material to form with the impurities and easily fusible slag which may be continuously tapped from the furnace. Electric smelting under these conditions has advantages over the ordinary method in that it may be made entirely continuous; that the walls of an electric furnace can be easily constructed of materials which are impervious to zinc vapours and which will not be corroded by the slag, thus enabling the temperature to be raised to a point at which all of the zinc will be expelled from the ore; and that the heat is applied internally, thus preventing the large waste of thermal energy occurring in the ordinary smelting process. Ores high in iron and other impurities could be easily smelted, as the walls of an electric furnace can be made of materials which will withstand the corrosive action of the slags.

It seems possible that zinc sulphide might be economically smelted in the electric furnace, without a preliminary roasting, if ore, lime and carbon be mixed in proportions required for producing metallic zinc, calcium sulphide and carbon monoxide. The fused calcium sulphide could then be tapped from the furnace and the sulphur subsequently recovered. All but

traces of the zinc can be distilled from such a charge, as is shown by one of the experiments previously given in which the residue remaining in the furnace contained only 0.13 per cent. of zinc.

It is a question of only a few years until someone will devise an electric furnace process by which zinc ores, high in iron, etc., and which cannot be treated by the old method, can be economically smelted and by which practically all of the zinc in the ore will be saved.

A Handsome Electric Car

THE development which has been attained in electric car design is well illustrated in the accompanying illustration of a new car recently built for the Western Massachusetts Street Railway Company by the Laconia Car Company Works, of Laconia, N. H. It is safe to say that this car is one of the handsomest ever built for regular passenger service, and in artistic beauty of finish, ease of riding and comfort, it is rivaled on the same road only by a similar car built under competitive designs by the Wason Manufacturing Company, of Brightwood, Mass.

The Western Massachusetts road operates in the valley of the Westfield River, a Berkshire region noted for wild and picturesque scenery, and the new cars were designed to secure the greatest possible freedom of vision consistent with safe and durable construction. The car shown herewith is 40 feet 9 inches long over bumpers, and 8 feet 4⅝ inches wide over all, the height from the rail to the top of the trolley board being 11 feet 11 inches.

Perhaps the most striking feature is the window design. On each side are five windows of polished plate glass, 52 inches wide and 24 inches high, weighing about 50 pounds each, but arranged to drop with ease through the use of counterbalances. From the interior of the car the out-of-door views are therefore seen with the greatest ease, and the observation end of a Pullman car has little to offer in the way of advantages over the Laconia electric.

The interior is finished in highly figured Tobasco mahogany, inlaid. The ceiling is of the full Empire pattern, finished in gold bronze; the trimmings are of oxidized bronze with beaded effect, and the seats are of Royal blue plush with high backs. The curtains are of blue silk and the aisle is equipped with interlocking tiling. A notable feature is the inside lighting, which is effected by strings of five lights each, arranged in the ceiling between arches, with 16-candle-power frosted bulbs and oxidized bronze husks. There are sixteen cross reversible seats and four corner seats placed longitudinally.

The car is mounted upon two Laconia cushioned swing bolster trucks arranged for inside-hung motors, the wheel base being 5 feet 7 inches, with 33-inch steel-tired wheels, and 4½-inch axles. Providence fenders and four General Electric 40-H. P. motors with multiple-unit control are installed. Although the first cost of such a car as this is necessarily high, the management of the road feels that the use of this character of rolling stock will be a constant means of attracting desirable traffic, and this has been the experience thus far enjoyed.

AN ELECTRIC CAR BUILT FOR THE WESTERN MASSACHUSETTS RAILWAY COMPANY BY THE LACONIA CAR COMPANY, LACONIA, N. H.

The Mont Blanc Electric Railway

WORK was recently commenced on the construction of an electric railway to reach the summit of Mont Blanc, in the Swiss Alps. The road is to be about 12 miles long, and it is expected that five or six years will be required to finish it. The style of construction is to be patterned after that of the Jungfrau system, which is now operating. The cars will be run in trains, each train composed of an electric locomotive and two saloon carriages and capable of accommodating 80 passengers. The cars will be lighted and heated by electricity. Three independent sets of very powerful brakes are expected to make impossible any accident due to brake failure. Telephones will be installed to connect stations along the line. The journey will require about four hours, and a fare of $20 probably will be charged.

Opening of the Philadelphia Subway

ON December 18, the completed section of the Philadelphia subway, extending under Market Street from Fifteenth Street to the Schuylkill River, was opened to traffic. The Schuylkill River is crossed on a new bridge, the express trains running into West Philadelphia on an elevated structure.

Four tracks are provided, two for express trains and two for surface cars, except that part east of Fifteenth Street, which will have two tracks for express trains only. No ballast is used for the tracks, so that they may be thoroughly flushed with water and drained by means of sumps. On the local tracks, the rails are mounted on cast-iron chairs, the whole being embedded in concrete. Except at crossovers, the express rails are mounted on yellow pine blocks 6 by 24 by 10 inches, which in turn are placed on channels set in concrete.

For ventilation, the station entrances will be partly relied on, but in addition, chambers are provided, connected to stacks, at the bottom of which fans may be placed. The cars will have side and end doors, the latter being opened by compressed air.

It is reported that the Canadian Pacific Railway is to electrify some of its branch lines in the Province of Quebec.

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Leading Articles

Picking Up Wireless Messages

A RECENT communication from Washington, D. C., announces that the United States Navy has been successful in obtaining a means whereby it will be able to read any other wireless message that may be traversing space within reasonable distances. The announcement conveys the impression that there is something novel in being able so to do. As a matter of fact, however, nothing is better known in the wireless telegraph art than that by suitable tuning apparatus, and with a sufficiently sensitive detector it is perfectly feasible to pick up any electric waves that may be passing. It is known, for instance, that wireless stations in Germany have picked up signals transmitted from Poldhu and have reported back the length of the electric wave used at that station. There is at present no known method by which outsiders may be prevented from receiving wireless messages when the signals are of sufficient strength, and not confused by the presence of other signals. The use of a cipher code may render translation of the message difficult, but, as long experience has shown, not impossible. The method employed in some navies to prevent a more or less remote station from intercepting the wireless messages exchanged between the vessels of a fleet consists in the use of short vertical wires, weak transmitters and sensitive detectors. This plan has the merit of practicability, for obviously a message that does not reach a station cannot well be received.

Thawing Water Pipes Electrically

THE thawing of frozen water pipes by electricity is now so well recognized as possessing the advantages of rapidity, cheapness and certainty, that a pipe-thawing transformer outfit has become an established means of increased earnings to the electric power companies in towns and cities having a public water supply. The experience of the past few winters has fully justified any outlay for such an equipment, and the prospective purchaser has now several types to select from.

With the taking away of one of the plumber's fruitful sources of revenue, it is natural that he should seek to decry the electrical method of thawing pipes. In several instances, during the past winter, it was claimed that electrolytic action during the process of thawing had damaged the pipes. In one case, a plumber reported that a lead pipe had burst because it "had had electricity on it." As the average person is ignorant of electrolytic action and the difference between direct and alternating current, these statements have had weight and caused some uneasiness, but with the increasing use of the method and the assurance of the power companies of its harmlessness, the false impression will doubtless be entirely removed in time.

The charge for thawing pipes as given in the reports of companies using this method, have varied within wide limits,—$1 being the lowest and $25 the highest. The lower limit seems rather absurd when compared to the customary charges of the plumber, while the higher limit compares favorably with those charges. Five dollars was found to be a reasonable charge for small towns and $10 for larger places, while $15 or $25 was surely little enough in some cases for immunity from delay and the digging up of lawns or pavements. As to the profit in the work, one company, charging a uniform rate of $10, was able in two weeks to earn five times the cost of the outfit.

The time of thawing, of course, varies with the conditions. In one case, only one minute was required to thaw 200 feet of ¾-inch pipe, using 120 amperes at 50 volts. In another case, where the size and length of the pipe were the same, six minutes were required with a 110-ampere current at 50 volts. In still another case, five hours were required to thaw 700 feet of 1-inch pipe with 175 amperes and 55 volts.

Sometimes the frozen pipe has refused to respond to the electric treatment, but on investigation it was found that either the service pipes

were connected to cement mains, or that they crossed larger pipes underground. A connection with the curb box instead of the usual one to a hydrant has generally remedied the trouble. Faulty couplings and unions have also been a source of trouble, but bridging the joint with copper overcame this difficulty. Another cause for failure has been bad connections and too little copper between the transformer and the pipe. "Plenty of copper and good connections" is a maxim to be followed in this work.

Telephones in New York City

IN the first rank of industrial development during the past year, the tremendous increase in the number of telephones installed by the New York Telephone Company in the boroughs of Manhattan and the Bronx forms a striking example of the wide-spread use of telephones in the city of New York. In the other three boroughs of the city, the growth has been correspondingly large, and in these boroughs the New York & New Jersey Telephone Company has met with a development which was not anticipated at the beginning of the past year.

The growth of the telephone system in Manhattan Borough has been particularly constant during the last twelve months, although the last few months have seen a somewhat higher increase in new telephones than at the beginning of the year. Over 35,000 new telephones were contracted for during 1905 in the boroughs of Manhattan and the Bronx, figures which have never been reached before, and which, in fact, were not fully anticipated twelve months ago.

New York is not the only city in the country where a large increase in the extent of the telephone system is being made. In fact, there seems to be a wave of telephone development from one end of the land to the other, and it is only natural that New York should take a commanding position in the rapid increase.

The distribution of the growth has been fairly even throughout the length and breadth of Manhattan Island, but it has been particularly heavy in comparison with other years in the residential section, especially in the vicinity of Central Park and in Harlem. A number of factors have contributed to this growth, among which is the reduction in rates, which went into effect in May and June, and applied to all classes of service which were then offered.

The opening of the rapid transit subway also had a marked effect on building operations in the northern part of Manhattan and in the Bronx, and accordingly a large number of apartment houses were planned and built, most of which provided for a complete system of telephones operated through the popular private branch exchange system—each room being equipped with a telephone. More than 500 apartment houses now have private branch exchange systems, providing for over 15,000 telephones. Every hotel in Manhattan of any prominence has a private branch exchange system with a telephone in each room, and adequate booths in convenient places for the use of the telephone by the public. More than 160 hotels are thus equipped, containing over 22,000 telephones. In order to accommodate this present growth and to anticipate for the future, four new exchanges in Manhattan have been provided for, and in the next year or two even more exchanges will have to be opened.

The general offices of the telephone company are located in the building extending from Cortlandt Street to Dey Street, and known as 18 Cortlandt Street and 15 Dey Street. The increase in the number of employees of the company and the necessity for providing more space for office purposes, necessitated the addition of a fifteen-story extension to this building on Dey Street. In this new building the contract department will have new and spacious quarters, and the other departments of the company, which come in contact with the public will also be so equipped.

The largest gain from any one class of subscribers will undoubtedly be among the department stores, several of which have already planned for elaborate telephone systems, some of them having as many as 1000 telephones under one roof. The managers of the department stores realize the tremendous amount of shopping that can be done by telephone, and as the growth of telephones in the residential section has been very heavy during the past few years, most of their best customers are in a position to use immediately the new facilities which the installation of large telephone systems in the department stores will present. The presence of these large department-store systems will also serve to stimulate additional residence telephone development, and not only will the large stores welcome the idea of selling goods by telephone, but the small retail stores will also see the tremendous advantage of personal selection of goods by telephone on the part of their customers.

While the greater part of the new telephones which will be installed during this year will undoubtedly come in the middle and upper sections of Manhattan, the business section will also experience a similar growth.

The private branch exchange system has become popular and is offered at such reasonable rates that owners of small establishments, limited to only one or two offices, are installing this class of telephone service. Business people realize that with only one telephone, their business must necessarily suffer when the line is frequently reported "busy," and they gladly welcome a system which will give them more than one connection with a central office.

In looking forward to the telephone development in the city of New York during the present year, estimates have been made which place the prospective gain in telephones at fully 75,000, two-thirds of this gain being accredited to Manhattan.

Developing Electric Lamp Sales

A RECENT report of the advertising committee of the Licensed Manufacturers of Incandescent Lamps on methods of increasing the sales of incandescent lamps, suggests the formation of a Co-operative Electrical Development Association for this purpose.

It is proposed to form this association in the firm belief that there exist certain practical and profitable lines of co-operative work, which electrical manufacturers generally, although competitors in similar and dissimilar apparatus and supplies, not only can, but should, undertake in co-operation with central electric lighting stations, and all intermediary electrical interests, for the purpose of stimulating in every possible manner the increased use of current-consuming devices by the public in the field of light, heat, and power, as against competition for similar purposes, of gas, gasoline, acetylene, oil, and other illuminants.

The incandescent lamp manufacturers and other electrical manufacturers co-operating with them, have already appropriated $20,000 for the initiation of the work of increasing the consumption of lamps, under the supervision of an advertising committee, and considerable progress has been made in perfecting detailed plans for the campaign.

In line with the objects of this movement, and directly as a result, and in co-operation with it, other electrical and allied interests have

made plans for the expenditure, during the year 1906, of not less than $45,000, so that the formal inauguration of the movement this month will be backed with $65,000 of money energy.

It is estimated that the activities of the association, as planned, could be reasonably expected to increase the demand for electrical apparatus and supplies $1,913,333, or 1.34 per cent., above the normal rate of growth. This amount of added business, if yielding the manufacturers a profit of 15 per cent., would cover the appropriation suggested, namely, $287,000.

The American Institute of Electrical Engineers Building Fund

IN view of the great importance and utility of the United Engineering Building, at New York, as a home and center for the engineering professions and arts, the General Electric Company has made a contribution of $25,000 to the land and building fund of the American Institute of Electrical Engineers. President C. A. Coffin, of the General Electric Company, who takes a warm personal interest in the matter, has also sent his own check for $5,000. The committee, which had already received gifts and pledges amounting to nearly $70,000, is greatly encouraged by this generous support of its work.

The fund is now, with other new contributions, well over $100,000, and with renewed energy the committee has begun its canvas of the field with the object of securing the second necessary $100,000. About 600 members have already subscribed to the fund, and the committee expects to have no difficulty in at least doubling this number. It has just issued to the whole membership a handsome pamphlet, illustrating and describing the new building in course of erection in New York City, and detailing the steps that have been taken by the associated engineering bodies to give effect to Mr. Carnegie's original gift.

A new direct-current traction motor has been brought out by the Oerlikon Company, of Zurich, Switzerland, in which the distinguishing feature is the placing of auxiliary poles between the main pole pieces, with the winding in series with the armature. The motor in this respect is similar to those of American design for stationary use, the object of the "interpoles" being, of course, to preserve the commutation field.

Power Transmission from Victoria Falls

THE practicability of the proposal by the British South Africa Company to transmit high-tension direct current from Victoria Falls, in the Zambesi River, to Johannesburg—a distance of 556 miles in a direct line, or 745 miles by the new railroad through Pietersburg and Gwanda,—has been called into question by Prof. W. E. Ayrton, in a recent issue of the engineering supplement of "The London Times."

Owing to the lack of a market for power along the route of transmission, the great expense of construction and maintenance, and because excellent coal can be delivered at the Rand at from $2.50 to $3 a ton, he argues that the scheme would not be commercially successful. At present, the cost of one horse-power year at the Rand is $100. To a 24-hour customer in Buffalo, Niagara power is transmitted 30 miles and sold for the same price. On this basis, power could not be transmitted 745 miles and sold at rates to compete with the present one. Moreover, the danger from native interference with the transmission line would be great, and any interruption of service would be a serious matter in mines where human life depends on the operation of ventilating and pumping machinery.

Opposed to Professor Ayrton's opinion, however, are those of M. Tissot, M. Blondel, Gisbert Kapp, and Ralph D. Mershon, that the scheme is commercially feasible. The Thury system of high-tension, direct-current transmission is now employed to some extent on the continent, the highest voltage being 15,000, and another line, on which the voltage is to be 57,000, is now under way The Zambesi power scheme proposes the use of a similar system with a voltage of 140,000. The reasons given for the adoption of the direct-current system are, that at equal voltages the same power can be sent over smaller and consequently less expensive conductors, and that higher voltages can be employed with direct current than is practicable with the alternating-current system.

To obtain the pressure of 140,000 volts, a number of generators are connected in series, and the center point of the generating system is earthed so that the pressure of each conductor above earth is 70,000 volts. As to overcoming commutator difficulties, in the 57,000-volt line M. Thury has succeeded to the extent of using 3560-volt machines, four of these machines being driven by each turbine. The insulating coupling necessary between the generators and the turbines is to be improved to withstand double the present voltage.

The line will consist of aluminium cables supported on steel towers, the insulators probably being of the same type now in use on high-tension lines in America, though naturally of greater dimensions to withstand the higher voltage.

Electrification of the Road

THE Erie Railroad Company has decided to parallel a large part of the main line in New York with trolley lines. Plans have been formulated for the construction of a line between Binghamton and Corning, 76 miles, and other stretches will be built later through the more populous parts of the State.

This project is separate from the proposed electrification of the Erie's suburban lines in New Jersey. It has been rumored for some time that the Erie's four-track lines across New Jersey would be electrified, but no decision has been reached yet in regard to this. The company was forced to take this action, owing to the threatened construction of rival trolley lines paralleling their steam roads.

Surveys have already been made for the line between Binghamton and Corning, and contracts will soon be let for the construction of a third track. This track will parallel the present main line, except in passing through large cities, where a detour around the yards will be made. Work will be begun in the early spring. The line will be standardized, laid with 90-pound rails and provided with special equipment for local service. It will cost $1,500,000. The new line will run west from Binghamton through Endicott, Union, Owego, Waverly, Chemung, Wellsburg, Elmira and Horseheads to Corning, where for the present it will terminate.

It is reported that a bill has been introduced in the Mexican Congress making the theft of copper wire, used for transmission lines, a capital offense if a fatal accident to any one results in consequence of such theft. Over $30,000 worth of copper wire was recently stolen in the City of Mexico.

It is reported that Buenos Ayres, Argentina, is to have a system of underground railways. German capital is said to be interested in the project.

Electricity in Manchuria and Siberia

Trade Possibilities for American Manufacturers

THE signing of the treaty of peace between Russia and Japan was the signal for renewal of the commercial and industrial development of Manchuria and Siberia. Without doubt, the effort to secure orders from these great regions in the Far East by the different nations, will be marked by intense competition. Japan recently placed heavy orders in America for electrical machinery, including equipments for a 28-mile electrical railway in Korea, several new generating sets for Tokio, and electrical mine equipments for the Kosaka Copper Mines. But Russia, as well as Japan, may be expected to develop the vast regions in Manchuria and Siberian Russia.

In these electricity has perhaps received less attention than in any other territory of similar size and possibilities. The land offers great inducements for the development of electricity by water-power, the country being well watered by many large streams. There are also important coal, iron, and copper mines. In the past dozen years Russia has shown a disposition to develop her mines in Siberia, and English and American companies have received a number of valuable concessions, but the war with Japan interrupted the proper working of them. The opening of the railroad through Siberia has paved the way for the introduction of foreign machinery into her mines, railroads, and manufacturing plants. Russia is not a manufacturing or mechanical nation, and most of her machinery is purchased either in Europe or America.

Electricity has already become a more important factor in Siberia and Manchuria than is generally believed, and the Japanese invading army has further stimulated its use. Continental manufacturers of electrical machinery have been more active in providing Siberia with equipments than have Americans, but as the Japanese are good buyers of American goods it is possible that a change may soon be made in this respect.

The Swiss manufacturers of turbines, electric generators and motors have been particularly successful in invading Siberia, and in the central stations of the leading cities along the line of the Siberian railroad, Swiss machinery is found most frequently. At the central station at Tomsk, belted dynamos made by Brown, Boveri & Company, of Switzerland, are in use. A Russian firm installed the steam engines for driving them. The boilers were also the work of Russian makers.

The station is a fairly profitable one, although the efficiency of the engines is comparatively low. The electricity is used for lighting the public buildings, a few public squares, and for private consumption. Four small manufacturing plants use electric power for driving small machines, and a few electric fans are driven in summer. While the short Siberian summers do not encourage manufacturers of fans to exploit this field very much, still their summers make up in intensity what they lack in length.

The central station at Tomsk is owned by the city. Wood is used as fuel. Tomsk is not situated favourably for the use either of coal or oil. The latter has to be brought from the Baku-Batym district. Most of it is used by the railroad, and very little so far has been employed for private manufacturing purposes. The adjacent forests, on the other hand, yield an abundance of wood, and this is used almost exclusively as fuel. This is an important point to keep in mind, since in bidding for the electrical and steam engineering trade of Siberia the fuel question must be considered. In nearly all other parts of Russia, oil is the leading fuel, and boilers and furnaces must be arranged accordingly.

There are central stations of fair size and importance at Omsk, Irkutsk, Vladivostok, Krasnoiarsk and Blagovechensk. Some of these stations use oil for fuel, and others wood, but only one uses coal. The stations are not unlike in general appearance and equipment. For the most part they have been built by local engineers and equipped with electrical machinery by Swiss builders.

The use of electric lights in the smaller towns is unknown, but the large manufacturing concerns are aware of the advantages of this form of light, and any improvements made in lighting will be in favour of electricity. There is said to be not a single gas plant in all Siberia and Manchuria. At Harbin, electricity has been adopted for lighting, and since the war the Russians have sent a great deal of electrical machinery to this place. Powerful electric search-lights and wireless telegraph equipments were needed. A temporary electrical station was erected during the war and will probably be increased in size.

The war also stimulated the use of the telephone. Until necessity demanded the telephone in the field, this instrument was found only in the towns, but now it is being introduced in the smaller villages and hamlets. The Siberian nights are long and gloomy, and in consequence the load factor should prove more profitable than in many other lands. The lights there would be used each night from one to three hours longer than in this country.

The wages of a station engineer will average $30 to $50 per month, depending upon his ability and work. A good man can be obtained at the former figure, and one accustomed to locate and make difficult repairs will not command more than $50 per month. The general manager of a central station in Tomsk, Omsk, and other equally large cities receives from $50 to $70 per month, although the latter salary is rather exceptional. Most of the mechanics are native born, as others are not attracted either by the wages or conditions of life. Telegraph operators have even fewer inducements, and the wonder is that enough could be obtained during the war to carry on the service.

In addition to the central stations owned by the municipalities, a few small private plants are owned and operated by commercial firms. The majority of these are found at Vladivostok. Altogether there probably are a score of firms who run their own electric plants for lighting. But throughout Siberia and Manchuria there are scarcely half a dozen plants of any size or importance that use electricity for power purposes. A few of the mines have been lighted by electricity, and current is now being employed for running light machinery in these mines. For instance, a num-

ber of mines in the gold regions are ventilated by electrically driven fans, and at least two of them have mine pumps operated by the same power. When we consider the vast mineral resources of Siberia, it is remarkable that electricity has not made more progress in lighting and driving machinery. But this is partly due to the fact that most of the mines are owned and run by the government, and that over 90 per cent. of them do not pay. They are run by incompetent men in many instances, and the methods of working them are of the crudest sort.

In the Ural district, and in the great trans-Baikal region the government has made some concessions to English and American mining engineers. A few of these mines are now worked somewhat according to modern engineering methods and it is here that one finds most of the electric lighting systems installed.

In the great oil regions of Russia, electricity has made some progress. Pumping for oil found at great depths has been tried by means of electric motor-driven pumps, and with the power generated from one central station an economy of operation has been demonstrated that speaks well for the future. Both American and English investors have secured control of some of the oil fields, and they are rapidly installing modern machinery and methods. Russia is a vast consumer of liquid fuel for generating steam for railways, steamships, and stationary plants. Its further use in generating electricity is a matter that, in the near future, will work great changes and improvements in Siberian Russia.

It is rather unfortunate for American and English manufacturers of electrical and other machinery for mines, industrial plants and central stations, that the Germans, Austrians, Belgians and French have already obtained a foothold in many of the Siberian towns. Their machinery has been adopted almost exclusively, but this is due probably to the fact that other nations have not sought this market so assiduously. It is only in the last few years that Americans have considered this far eastern region a worthy place for commercial exploitation. In Vladivostok, for example, there are German equipments owned by private concerns, but there is not a single American or English plant; yet from San Francisco American electrical machinery could be shipped to Vladivostok cheaper than from almost any of the European countries.

Russia is a long and slow creditor, and this feature is as characteristic of its people and private business firms as it is of the national government. Trade conditions are, therefore, not to the liking of the average American firm. Long credits are, however, cheerfully given by the Germans, Austrians, French, and Swiss manufacturers. Plants frequently have been installed a year before a second payment is made upon the machinery. Some of the plants have been in operation four and five years, and the builders have not yet received all of the payments due. Americans with their terms of cash are not welcome except among the few progressive firms who see the advantage of better materials at lower rates for shorter terms of credit. It may be that in the new trade developments, cash payments will be the only ones worth having, and in that event Americans will not be the losers.

Both Siberia and Manchuria are undeveloped markets which stand ready to open their doors freely to trade. That they are in great need of machinery, is felt both by the Japanese and the Russians, and these two nations will make strenuous efforts to outreach each other. It will be years before Japan will be in a position to make all of the machinery needed in Manchuria and Korea, and it will purchase most of its equipments in this country or in England. It is believed that Japan will teach China the value of machinery, and through co-operative efforts develop Manchuria as she has already developed her own country.

The building of railways in Manchuria is one of the most promising features of this prospective revival of trade. The Japanese are progressive constructors of electric railways, and the most civilized parts of Manchuria and Corea have been tentatively surveyed for new lines. It seems probable that every city of importance in these two countries will, within ten years, be provided with electric transportation facilities. Such, at least, is the opinion of our consuls in the Far East who have made a study of the situation. The same opinion is held by many regarding the electric lighting of these cities.

The telephone and telegraph have spread over Siberia and Manchuria more generally than has any other electrical business, and the war between Russia and Japan has tended to give an impetus to both these industries. Many temporary lines strung in the fields will remain and be improved for business purposes. Altogether, the electrical situation in either Manchuria or Siberia is most promising, and before long some big orders for equipments may be expected from this part of the Far East.

Electricity in the Cement Industry

CEMENT is divided into two classes, slag and natural cement. In the manufacture of natural cement the rock is taken from the quarry or mines and burnt in a kiln. It is then run through a conical crusher, or between rolls and ground into a powder, after which it is conveyed to screens which separate the cement which is fine enough to be packed. The coarser particles then go to fine grading machines which are ordinarily mill stones, or emery-faced stones.

Considerable power is required in these cement plates, and electric power is coming into wider use for them. Either the alternating or direct current system is adapted to this work, the choice depending on local conditions. The plant of the Iola Portland-Cement Works at Dallas, Texas, for example, is equipped with Westinghouse type S direct-current motors, and a contract just closed with the Santa Cruz Portland-Cement Company, San Francisco, Cal., gives a good idea of the size of some of these plants. This order calls for one 800-H. P. type C motor; ten 250-H. P., fifteen 150-H. P., one 75-H. P., and one 30-H. P. type CCL motors. These are all alternating-current motors of the induction type, and aggregate a total of 5655 H. P.

Three-Phase System for the Simplon Tunnel

A THREE-PHASE traction system is to be installed in the Simplon tunnel.

Three-phase alternating currents, with a voltage of 3000, will be employed. The ordinary trains will each be composed of a motor-car and two, three, or four ordinary cars. Heavy trains will be drawn by electric locomotives, two of which are actually being constructed by Messrs. Brown, Boveri & Co. Each will be of 1000 H. P. They will be tested over the Italian lines. The electric power will be supplied from Domodossola, a distance of 25 miles. The passenger trains will run at a speed of 40 miles per hour, and the cost is estimated at $193,000. The Swiss Government has accepted the proposition of the Italian Government to place five electric locomotives, supplied by Messrs. Ganz & Co. for the Valtellina line, at its disposal for use in the tunnel, which will be opened for public traffic on May 1, 1906.

Electricity in Little-Known Europe

By FELIX J. KOCH, A. B.

THE TELEGRAPH LINES IN TURKEY ARE OF PRIMITIVE CONSTRUCTION. OUTSIDE OF CONSTANTINOPLE ELECTRICITY IS ALMOST UNKNOWN

BOSNIA, THE EASTERN ADRIATIC, AND HUNGARY

IN Bosnia, a province of Turkey, the affairs of which are administered by Austria-Hungary, and which, less than thirty years ago, was in a worse state than is Macedonia to-day, electrical appliances are now in common use. In the monastery of the Trappists, at Banjaluka, electric lights are installed, the current being generated by water power. A telephone, too, is in use, connecting the monastery with the city.

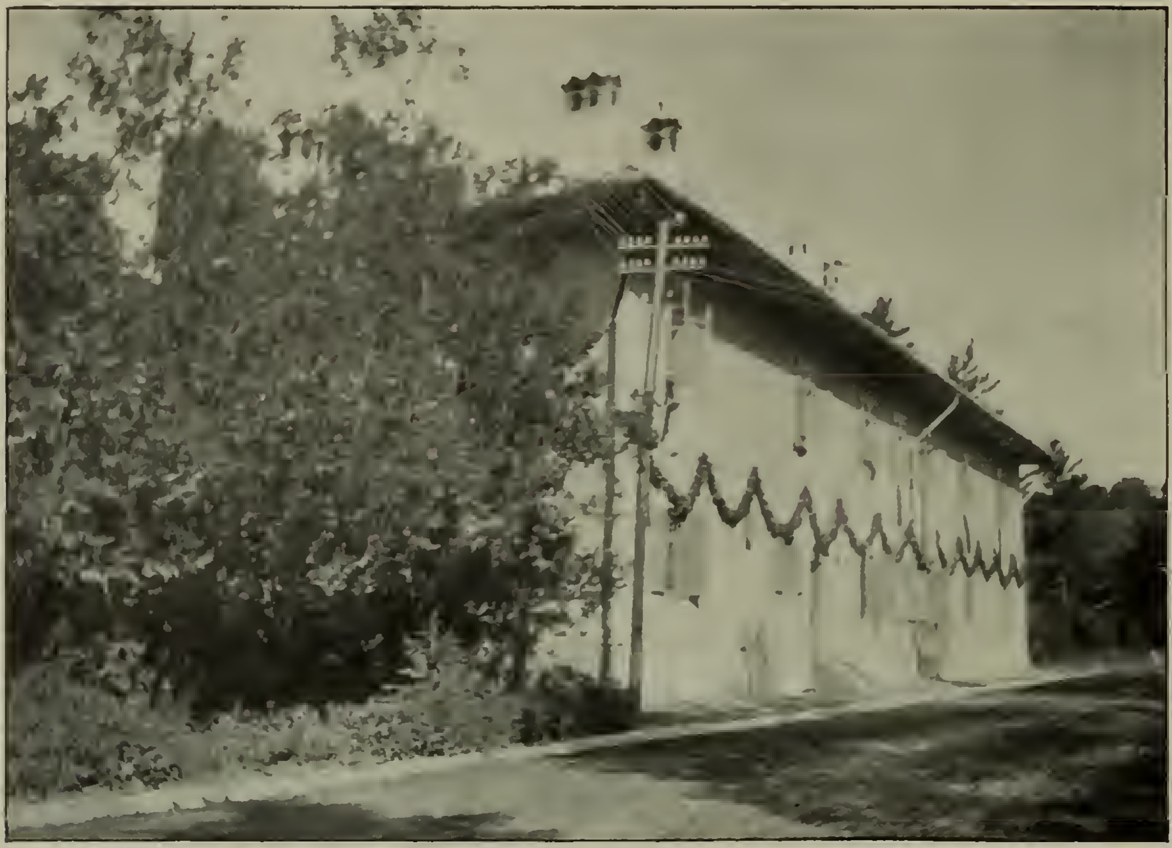
Through the canyons to Rjeka, where, in the seventies, one would scarcely dare ride, even under heavy military escort, to-day the telegraph wires are strung and remain unmolested. In the town itself, however, although there is a heavy waterfall that might be utilized for generating electric power, the rooms in the government hotels are still lighted with candles, and one pays for the entire candle, no matter what portion of it is used.

At Sarajevo, the capital, the applications of electricity are many. The hotels have electric lights and electric call-bell service. Arc lamps light the fine, wide streets, and electric street cars run along the quay. On the celebration of the Austrian Emperor's birthday, the barracks are decorated with coloured electric lights, but most of the private houses still content themselves with putting diminutive stairs in the windows, and on each of these mounting candles. Stores, however, are on this occasion aglow with incandescent lamps, in strong contrast to the oil cups, outlining the several bridges, and burning in the balconies of the mosques.

Gas works are not in existence in the city, and there is comparatively little electric lighting in the houses, so that the distant forts on the mountains and the public buildings in the city, all lighted with electric lights,

OIL LAMPS ON THE BRIDGE AT MOSTAR, IN TURKEY. IN MANY PLACES THESE ARE THE ONLY SOURCES OF ILLUMINATION FOR THE STREETS

THE PRINCE OF MONTENEGRO STARTING FROM CETIGNE TO ANTIVARI TO OPEN THE TRANS-MONTENEGRIN WIRELESS TELEGRAPH SYSTEM AND CONFER THE "GRAND CORDON" ON MARCONI



TELEGRAPH WIRES IN SERVIA. THESE ARE OWNED BY THE GOVERNMENT, AND OUTSIDE OF BELGRADE, THE CAPITAL, ARE THE ONLY EXTERNAL SIGNS OF THE USE OF ELECTRICITY

impress the peasant strongly as to the power of the Emperor.

In the Hungarian commercial museum at Sarajevo, samples of all Hungarian products, which it might pay the Bosniacs to investigate, are placed; and besides other things, orders for telephones are taken and filled. In the great brewery at Sarajevo, the cellars are electrically lighted, and the generators in the electric plant are of a modern type. Between the railway depot and the post office, also, the mail is carried by electric cars. The sausage industry in the city also uses electric power.

The railway cars of Southern Europe operate their lights on a peculiar system. The electric lights are on all night, and, as there are no sleeping-cars, with five or six companions in the narrow face-to-face compartment, the effort to sleep with the light on is a difficult task. Accordingly two cloths are bound about the globe, and all willing, these are drawn down, and the compartment is darkened.

In the hotels at Trieste, in Austria, electric light is made a separate item on every bill, whether one uses it in his chamber or not.

At Zara, the capital of the Austrian province of Dalmatia, on the Eastern Adriatic, electric lights are in use in the hotel, but candles are furnished nevertheless. The electric call-bell, too, has been installed. At Sebenico, also in Dalmatia, the same is true, the power being generated by the falls of the Kerka, some miles away. Here, however, a little Parisian electric night-lamp is set beside each bed. The mills where the famous Dalmatian insect powder is ground, are also run by electric power.

Away up in the heart of the principality of Montenegro, at Cetigne, the capital, electric lights and the call-bell are installed. There the government owns and operates the telegraph system, as it does in Hungary and Bosnia, and in the summer of 1904, wireless telegraph connection was made between Cetigne and Antivarri, Marconi attending in person, and being decorated with the Grand Cordon of Montenegro by the Prince.

At Budapest, the capital of Hungary, electrical appliances are in common use. Stores selling "American electrical novelties" are decidedly characteristic of the city, and electric flat-irons and like appliances are obtainable. The telephone is in common use, and the telegraph wires connect with practically all points in the kingdom. In other ways, however, the use of electricity is meagre; the subway, for example, being illuminated at the larger stations only. In the street cars the conductor on the rear platform pushes a button to ring the bell at the motorman's side, instead of pulling a rope.

To the North, among the Carpathian Mountains, the ice caverns are lighted with electricity, and in order to bring tourists into the region of the Höhe Tatra, an electric car runs from the town of Poprad to Schmecks. This car is of the trackless trolley type, being fitted with heavy rubber tires. The wires are strung at one side of the country road. In the front of the car the motor is tended by a motorman and a brakeman, while the conductor stands in the rear. The car, which is a splendid yellow affair, can go about 22 kilometers ($13\frac{1}{2}$ miles) an hour, but its speed is now limited to 10. Twenty-five passengers can be ac-

THE TELEPHONE WIRES IN SARAJEVO, THE CAPITAL OF BOSNIA, ARE ONE OF MANY INDICATIONS OF THE USE OF ELECTRICITY

commodated. Water power is used to generate the current.

SERVIA AND ROUMANIA

In Servia and Roumania, at least one automobile concern, of Detroit, building electric motor cars, has seen fit to send its agent to Belgrade, the capital of Servia. While the agent left in disgust at the Serbs way of doing business, before he had been a week in the town, at least a start was made. Whether it will be continued is doubtful, since the Serbs need to be shown the very rudiments of making purchases, even as to obtaining drafts on London, and but few can show a credit exceeding ten thousand dollars.

Electric light, however, is comparatively common in Belgrade. From the offices of the Secretary of State down, its use is apparent on every hand. The telegraph belongs to the government, and rates are low. Cables, however, are high, and the rate for eight words from Belgrade to Chicago, including the name and address of the recipient, and the name of the sender, is $3.85.

In many of the byways of the capital there are no street lights whatever, and so storekeepers place an electric light before the doorway. Many of the churches, notably that in which the coronations are held, could well stand electric lighting. At present the tapers keep the interiors dark and dim. That a source of current supply would not be unobtainable, is evident from the poles for the arc lamps just outside. On the occasion of fetes the city is illuminated, for the most part by candles and oil lamps, though here and there electric lights of several colours are arranged, with a background of candles.

Belgrade has its electric street cars, too. Other cities of the kingdom, however, have but few applications of electricity outside of the telegraph. Along the railway to the Turkish frontier one sees the slanting telegraph poles, and these, too, follow the Danube to Orsova.

Bucarest, the capital of Roumania, a miniature Paris, has its handsome stores brilliantly lighted with electricity, so much so that the boulevards, in the evening, remind one of the mercantile districts of an American city at Christmas shopping season. In fact, it seems doubtful if, sooner or later, electricity will not supplant the candles in the Greek Orthodox Churches.

Bucarest, too, has its electric street car, built like the winter cars of American traction systems. They are cleaner, however, and halt from time to time, that the floor may be sprinkled and all dust laid. Advertisements, too, are absent from these cars. The fare is about three cents.

THE RAILWAY AND THE TELEGRAPH, THROUGH THE CANYONS TO RJEKA IN BOSNIA, HAVE DRIVEN OUT THE BRIGANDS WHO FORMERLY MADE TRAVEL UNSAFE

THE MINISTRY OF POST AND TELEGRAPH IN SOFIA, THE CAPITAL OF BULGARIA. THIS CITY HAS AN ELECTRIC STREET RAILWAY, AND TELEPHONE AND ELECTRIC LIGHTING SYSTEMS ARE INSTALLED TO SOME EXTENT

Owing to their dire poverty, the Roumanian villages, even more than those of Servia, have slight hope of seeing other applications of electricity than the government telegraph and the long-distance telephone. The latter is employed to notify mayors of villages when strangers are coming, whether these may halt in the town or no, since without such permit from the national or district capital, no stranger may halt at a village.

Here and there in Roumania one meets with intelligent men who have grasped at forlorn hopes and studied electrical engineering, only to find, to-day, that there is no work there for them to do. They are therefore forced to fall back upon other more usual occupations.

TURKEY AND BULGARIA

Throughout Turkey, aside from Constantinople, electricity is unknown, save as it is employed in the telegraph lines paralleling the railroad. In Saloncia civilization is well advanced and only the fact that it is not permitted, prevents the installation of electric light, or the substitution of electric traction for the horse car. At Uscup, too, the feeble oil lamps along the streets, and at Adrianople, the little urns of oil placed in the minarets to celebrate the anniversary of the Sultan's accession, might easily be replaced.

The interior of Bulgaria is notably deficient in electrical appliances. At Rustchuk, the commercial metropolis, one lights himself to bed with a candle. At Tisnova there is a fire tower, as on the island of Nantucket, in place of an electric fire-alarm system. On the trains to Sofia, oil, instead of electric light, burns feebly. At Sofia itself, the capital of the principality, electric light, however, is installed in the hotel; but whether used or not, it is charged on the bill at the rate of eight cents a night. Electric street cars run here, and the Prince's stables are lighted with incandescent lamps. In the newspaper offices, telephones and the American "Hello" are used. In the principal theater, too, there, electric lights are used. The telegraph, a government institution, reaches the main towns of Bulgaria only.

The First Ganz Three-Phase System in America

THE first electric line in America to be equipped with the Ganz three-phase system is now being built between London and Port Stanley, Ontario. The length of line now under construction is 27 miles, split into two sections of 18 miles and 9 miles, to be run with three-phase current. Between these two sections is a third one of about 2 miles, belonging to the St. Thomas City Railway, and run by direct current. The cars of the Interurban road will run over the direct current section also, being furnished with a special equipment for this purpose.

The stator of the motor has a three-phase winding arranged in such a way that it may be fed with 1000 volts alternating current or 500 volts direct current. The rotor has a commutator and four sliding contract rings, it being a two-phase armature when running with alternating current.

Each car will have two motors, of a total rated horse-power of 130. The series-parallel control will be used for direct-current work, and the single-cascade control for alternating-current running. The trains to be hauled will weigh 35 tons and run at a maximum speed of 30 miles per hour. The line has several very heavy and long grades up to 5 per cent. The transmission voltage distribution is 10,000 volts, three-phase.

High-Tension, Direct-Current Transmission in Europe

IN an address before the British Civil and Mechanical Engineers' Society, W. B. Esson described the development of high-tension, direct-current transmission in Europe.

About 1889, he said, engineers on the Continent were faced with a very important problem. They saw in their waterfalls thousands of horse-power running to waste. They knew that by adopting electric transmission, this power could be utilized and distributed to great advantage among manufacturers scattered over a wide area, but they also recognized that success could be obtained only by the use of a pressure considerably higher than the 2000 or 3000 volts then in use.

The problem required a considerable amount of study, the position being,—for alternating currents, pressure all right, but no motor available; for continuous currents, motors available, but pressure not high enough. As the supply of power was the leading idea, the system which possessed the motor had to be chosen, and continuous current was consequently adopted, with the brilliant device, however, of joining up all the motors in series and spreading the high pressure over the lot, while connecting the generators in series to keep down the pressure on the commutators of individual machines. In this system the current is kept constant, the pressure varying according to requirements, and at that date it does not appear that there was any other way of providing a general power supply. It says much for the engineering of the installations on this system, that they are in most successful working today, and what is more, they are being added to in competition with the three-phase system.

A considerable number of installations on similar lines have been laid down, some of them of great importance. Among these is the Brescia transmission in Italy of 700 H. P. at 15,000 volts over a 12-mile line, and the larger installation for supplying the Swiss town of La Chaux-de-Fonds with 2400 H. P. at 14,400 volts over a 32-mile line. Another Swiss-French installation is at work transmitting 4000 H. P. at 22,000 volts over a 34-mile line from St. Maurice to Lausanne, and there is in course of construction the largest of all, designed to transmit 6000 H. P. at 60,000 volts over a line 114 miles long from Moutiers to Lyons.

Now a system showing such strong vitality, though working on what nine-tenths of our engineers would call antiquated lines, cannot be dismissed in a sentence. The facts are, that the system is going ahead in the face of the three-phase alternating system and is successful on a scale commensurate with many of the larger three-phase installations. The Americans say that the success of such a system would be impossible in their country, because the motors would not there get the careful and skilled attention given to them on the Continent. This may be so, but with a large plant and sub-stations the objection need not hold. In any case it is certain that every engineer will look forward with the greatest interest to the completion of the large scheme now in progress.

Hospitality of the Institution of Electrical Engineers

ARRANGEMENTS have been set on foot by the Council of the Institution of Electrical Engineers to entertain this year the kindred institutions in Europe and America. Official invitations to visit Great Britain as guests of the Institution have been sent to:—

The American Institute of Electrical Engineers.

The Canadian Electrical Association.

The Société Internationale des Electriciens.

The Associazione Elettrotecnica Italiana.

The Schweizerischer Elektrotechnischer Verein.

The Elektrotechnischer Verein.

The Verband Deutscher Elektrotechniker.

The date for the arrival of the guests has been fixed for the last week in June, 1906, and a visit will probably extend over about a fortnight. The programme exists, of course, in outline only as yet, but the present idea is to spend about one week in London, which will give an opportunity to the guests to see the new electrical developments, and to make excursions in the neighbourhood. It is then proposed to make a tour through some of the principal industrial centers in the United Kingdom to visit works, and provide local entertainments for the visitors.

Electrical and Mechanical Progress

An Electric Windlass for Ferry Use

AN ELECTRIC WINDLASS AT THE DESBROSSES STREET FERRY, IN NEW YORK, OF THE PENNSYLVANIA RAILROAD

THE delay caused by the inability of a team of horses to pull a heavily laden truck over the steeply inclined bridge leading to a ferryboat when the tide is high or low, is an experience with which passengers on ferryboats plying about New York are more or less familiar. Frequently in such cases the only way out is for the passengers to lend a hand with the rope tackle provided for such emergencies.

The possibilities of the electric windlass for this work seemed to have been overlooked until recently, when one was installed at the Desbrosses street ferry of the Pennsylvania Railroad. The simplicity of the outfit is evident from the illustration, for which we are indebted to the New York Edison Company. The electric windlass not only accomplishes in a short time what it took manual labor many minutes to do, but it saves wear and tear on the horses and harness, as well as the passengers' hands and patience.

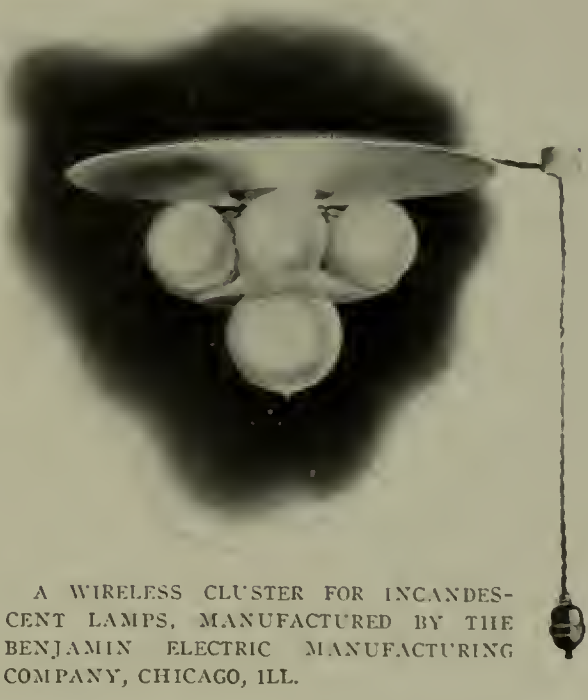
As will be seen from the illustration, the motor is placed below the floor, the winding spool and the motor controller being placed as shown. Two or three turns of the rope around the spool serve to bind it sufficiently to prevent slipping during the pull.

Electrically Operated Valves for the Cincinnati Filtration Plant

AN order for 149 electrically operated valves, to be installed in the Cincinnati filtration plant, has been placed with the Fairbanks Company, Elm and Broome streets, New York City, and the valves are being manufactured in the plant of the Pratt & Cady Company, Hartford, Conn. This order, it is claimed by the Fairbanks Company, is the largest of the kind ever given, and the valves, which are especially designed, will be particularly complete. They will be installed in 29 chambers and electrically operated from the floor above. There will be nine valves in the head chamber and five in each of the others. They will be geared to the floor stand on which is mounted the motor. The valves will be arranged so that they can be controlled from a distant point, and there will also be a switchboard in each chamber, on which will be mounted the controlling device to open and close the valves, which will be designed to take care of overload and underload at any point. The motors will be made by the Crocker-Wheeler Company, Ampere, N. J., and the controlling device will be manufactured by the Cutler-Hammer Mfg. Company, Milwaukee, Wis. There will be 106 sluice valves installed in the plant, and the contract for these has been awarded to the Coffin Valve Company, Boston, Mass. The first of the valves will be installed next spring.

Clusters for Incandescent Lamps

AN attractive incandescent lamp cluster manufactured by the Benjamin Electric Manufacturing Company, of Chicago, Ill., is



A WIRELESS CLUSTER FOR INCANDESCENT LAMPS, MANUFACTURED BY THE BENJAMIN ELECTRIC MANUFACTURING COMPANY, CHICAGO, ILL.

shown in the annexed illustration. It is known as the "Arc-Burst" and

consists of a group of meridian-type lamps in a wireless cluster with suitable reflectors. The 50-candle-power lamp placed in the bottom opening of each cluster is provided with its own reflector.

The cluster can be furnished with a "turn-down" device, by means of which the outer and inner lamps may be operated independently. Special shade holders permit the removal of the reflectors without disturbing the electrical connections.

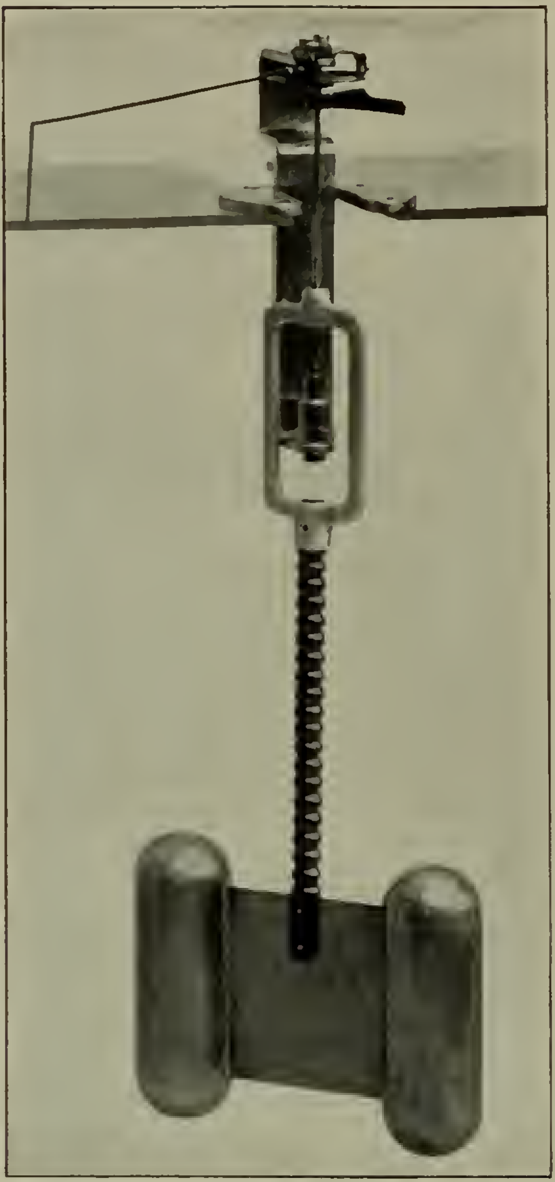
The cluster is made in four styles, namely, low-ceiling form, fixture form, suspension form, and out-door form. The illustration shows the ceiling form. This measures 18 inches in diameter, is 11 inches deep, and is for use on low ceilings or where it is not desirable to use a stem.

An Electrostatic Voltmeter for High Potentials

IN electrical testing and experimental work, high pressures are continually being used, and the measurement of these potentials is very often a perplexing problem. A number of different methods of high-pressure measurement have been used with varying degrees of success as to their accuracy, but all involve some uncertainty as to results. Where it is required that such apparatus as dynamos, transformers, cables, insulators, and the like, be subjected to a specified pressure test as a condition of their acceptance, controversy often arises as to whether the required voltage has been applied.

The ideal and theoretically correct method of high-potential measurement is that employing an electrostatic voltmeter, but certain obstacles, the principal one of which was the lack of an insulating medium of sufficient dielectric strength, have heretofore prevented the development and application of this type of instrument. The Westinghouse Electric & Manufacturing Company, of Pittsburg, has succeeded in overcoming these difficulties and in producing a meter that requires for its operation a negligible amount of energy, that is free from the effects of variation of wave form, and is direct reading. It is shown in the annexed illustrations. The faults inherent in all other methods of high-potential measurement, it is claimed, are entirely absent from this meter.

The operating elements of this instrument are immersed in a special grade of oil contained in a metal-lined wooden case with an insulated cover. The metal lining acts as a screen to prevent outside fields or influences from affecting the meter. As the insulation is one of the most important parts of an instrument of this type, a few of the advantages derived from the use of oil may be summarized as follows:—



THE MOVING ELEMENT OF THE ELECTROSTATIC VOLTMETER

AN ELECTROSTATIC VOLTMETER FOR HIGH POTENTIALS, MANUFACTURED BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG, PA.

1. The distance between the operating elements may be greatly lessened, thereby reducing the size of the instrument.
2. The actuating forces are greatly increased, due to the smaller distances between active parts and the high specific inductive capacity of the oil.
3. The reduction in distance between working parts of the meter makes possible a better form of scale.
4. The oil acts as a damper and makes the instrument nearly "dead beat" and easy to read.
5. The oil buoys up the moving element, thus removing practically all weight from the bearings.

The arrangement and relative position of the parts of the meter are shown in the diagram. The curved plates B_1 and B_2 are of such a shape and so arranged with respect to the moving element that a deflection in a positive direction shortens the gap between it and the plates. The charges induced on the two extremities of the moving element are of such a nature that they exert forces

of attraction on the charges on the plates. The turning of the moving element is restricted by a spring, and the deflection of the pointer is read between the plates. The horn-shaped terminals extend to the same distance below the oil as the suspension posts, and are also grooved so as

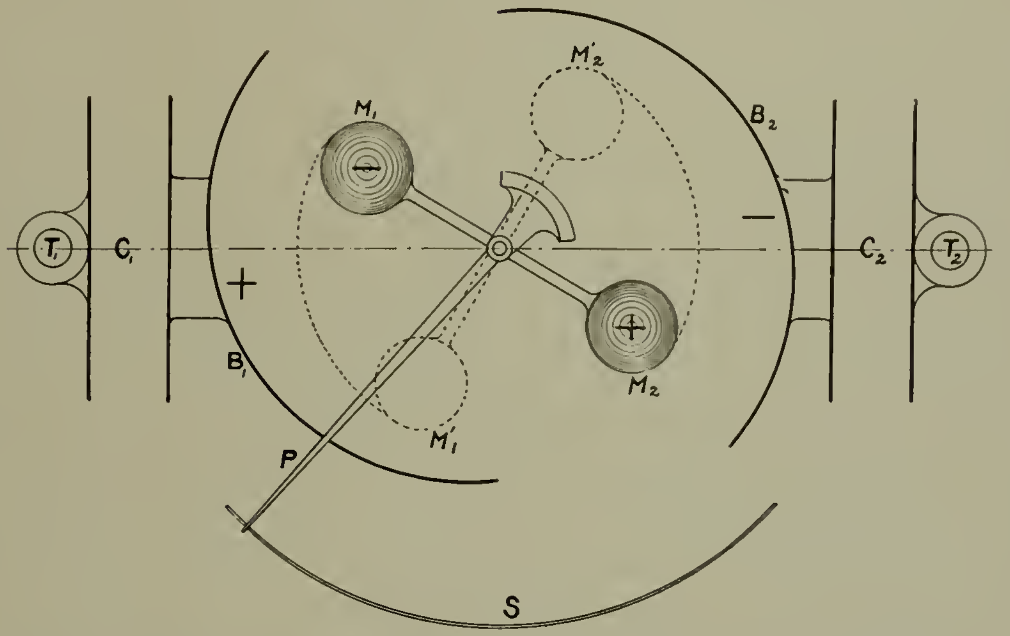
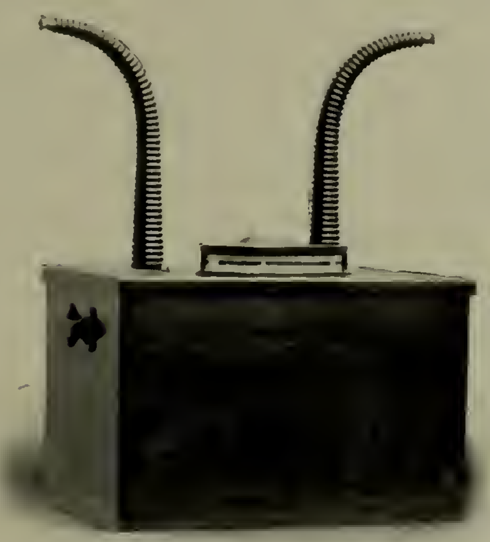


DIAGRAM SHOWING THE ARRANGEMENT OF PARTS OF THE WESTINGHOUSE ELECTROSTATIC VOLTMETER

on the scale. The condensers C_1 and C_2 are in series with other parts of the instrument, one plate of each being metallically connected to a curved plate, and the other to a terminal.



THE ELECTROSTATIC VOLTMETER ENCLOSED IN A WOODEN CASE

The instrument may be operated with either or both condensers short-circuited, thus giving a wide range to the meter.

The curved plates, with the condenser plates attached, are supported from the insulated cover by means of grooved posts of suitable insulating material. The separate condenser plates are supported in a similar manner. As all parts are firmly fastened to the same base, they are held in constant relation to each other, and no error can result due to disarrangement of parts. The height of the oil in the case, together with the long paths over the suspension posts, prevents leakage to prevent leakage over their surface.

The bearing springs and adjustments are similar to corresponding parts of Westinghouse standard indicating instruments. The cylindrical parts of the moving elements are hollow, and so proportioned that the buoyant effect of the oil removes almost all weight from the bearings, thereby eliminating friction and wear. The scale over which the pointer passes is placed on an edgewise cylindrical form similar to the scale of an edgewise switchboard instrument, and the reading may be taken from a safe distance. With the exception of the glass window through which the scale is read, the cover over the pointer is all metal, and acts as a screen to prevent external static fields from affecting the pointer.

Instruments of this type may be obtained for potentials as high as 200,000 volts. The one shown in the illustrations may be used for voltages up to 100,000 volts with the condensers in circuit, or for approximately 50,000 or 25,000 volts with one or both condensers short-circuited. The case is 22 inches long, 18 inches wide, and 15¼ inches high, with terminals projecting 18 inches above the case.

Motor-Driven Mail-Handling Machinery at the New Chicago Postoffice

An improved and thoroughly up-to-date motor-driven mail-handling conveying system was recently installed in the new Chicago postoffice by the Jeffrey Manufacturing Company, of Columbus, Ohio. On the sidewalk along Dearborn Street are thirteen ornamental iron mail boxes, under which are hung steel weighing hoppers in the basement of the building, each having a capacity of one ton of mail.

The process of handling mail on this side of the building is as follows:—

Wagons containing the mail in bags, sacks, and pouches, back up to the mail boxes, the doors of which are opened from below upon a signal from the driver, this operation ringing a bell and lighting an electric lamp at the hopper to be weighed.

THE MAIL-HANDLING MACHINERY IN THE NEW CHICAGO POSTOFFICE IS MOTOR-DRIVEN, AND WAS INSTALLED BY THE JEFFREY MANUFACTURING COMPANY, OF COLUMBUS, OHIO. THE WEIGHING HOPPERS AND CONVEYORS IN THE BASEMENT ARE SHOWN HERE

The bags are thrown through the street door of the box into the weighing hoppers, the weight of the mail is recorded by a recording beam scale, and the sacks are then dumped

on a horizontal 36-inch belt conveyor running under the line of the mail boxes.

This conveyor delivers the bags to an inclined belt conveyor running at a high speed, and this in turn delivers

A PART OF THE MAIL-HANDLING SYSTEM INSTALLED BY THE JEFFREY MANUFACTURING COMPANY IN THE CHICAGO POSTOFFICE

them into a 48-inch belt conveyor traveling at a right angle to the 36-inch conveyors. The 48-inch conveyor carries the bags to the foot end of the elevator and discharges automatically into the elevator boot.

The elevators consist of buckets 40 inches wide by 4 feet 6 inches long, hung on a double strand of 24-inch pitch roller chain, running at a speed of 60 feet a minute. They take the mail bags and pouches, as well as carriers' satchels, up to the second floor of the building and discharge them on the floor, where they are picked up by trucks and delivered to the different sorting points of the distributing floor, going directly to the various "States."

All the belt conveyors of this system run on ball-bearing rolls and are driven by chains from direct-current electric motors. The elevators are geared directly to their motors. There are three independent conveyor systems, as described above, on the east side of the building, each consisting of three belt conveyors and one elevator.

On the other side of the building, the conveying system consists of four bucket elevators, which are loaded by hand from the mailing platform in the basement driveway of the building. Two of these elevators discharge on the first floor, while the other two discharge the mail on the second floor. They consist of steel buckets 29 inches wide by 4 feet 6 inches long, hung on double strand of 24-inch pitch roller chain and spaced 4 feet apart.

From the tunnel system of the city, by which the mail will be brought from all the depots, a separate conveyor set is now being installed. This consists of a belt conveyor, running between two tracks of the underground tunnel system for 140 feet, then rising to a chamber over the tunnel system and under the driveway of the post office. In this chamber the bags of mail are automatically reloaded on a 5-foot belt conveyor, which discharges the mail on the receiving floor of the post office. The enormous amount of mail coming into the postoffice by the underground tunnels will be appreciated when it is considered that the system must discharge 300 bags a minute at some hours of the day. This would make a pile as big as a cottage in five minutes.

Another conveying system, running from the first floor to the second floor, consists of two inclined belt conveyors with steel pans riveted to the belt discharging loose letters on a sorting table. These conveyors receive all the loose mail, packages and pouches delivered by the public through the letter drops and windows of the city division, and discharge the mail on tables on the second floor, where it is sorted and distributed in the proper state sub-divisions.

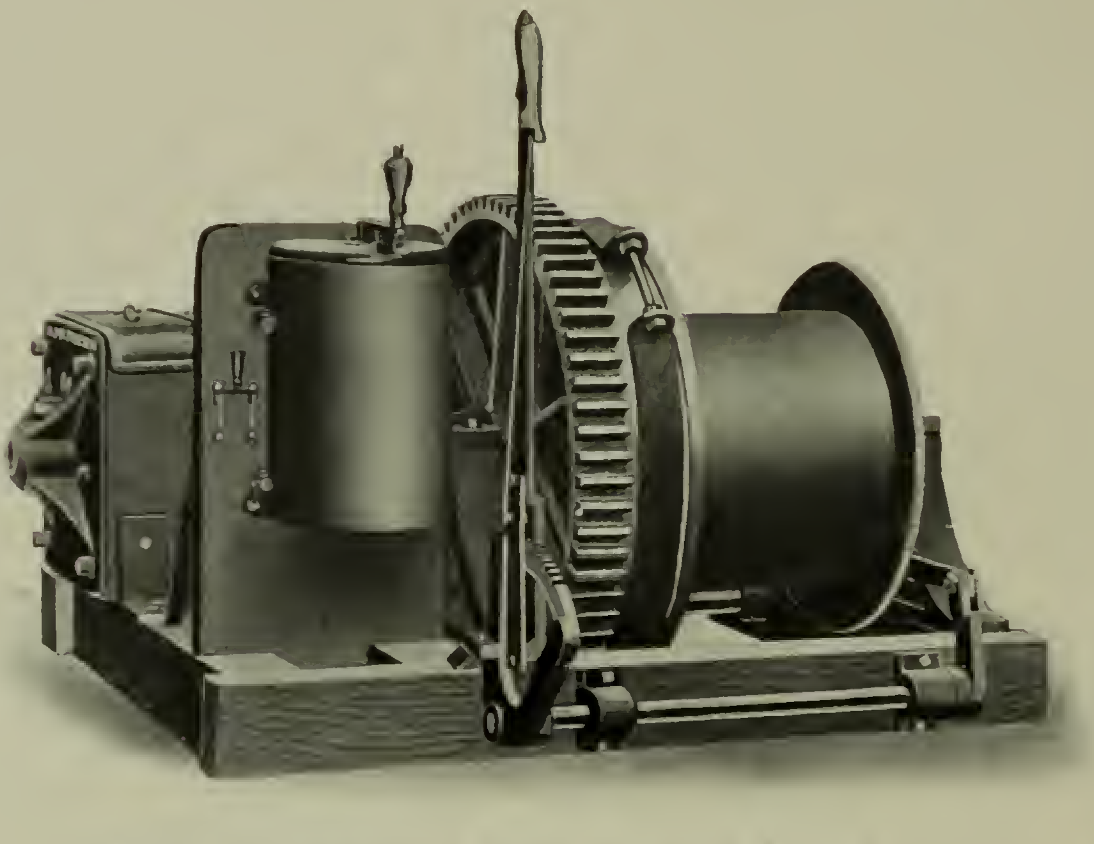
The money order division has also been provided with a belt conveying system to carry money order applications from the clerks' windows to the cashier's desk. This consists of a rubber belt with longitudinal corrugations to prevent the sheets of paper sticking to the belt; the machinery is concealed under the counter on which the money orders are made out.

A Motor-Driven Hoist

An electric motor of the box type, built by the Northern Electrical Manufacturing Company, of Madison, Wis., is shown in the accompanying illustration, driving a mining hoist.

This motor is claimed to be dust-proof, and is so designed that it may be used for out-of-door service without requiring any special protection from the weather or rain. The hoist as a whole is self-contained; it can be located wherever most convenient, and requires no help for operation except one man to control the different levers. If deemed necessary, however, it can be controlled from a distance.

Aside from its application to mining, this motor-driven hoist is serviceable in modern construction work. The motor is built with bosses, which can be drilled and tapped for fastening to the machine to be driven, or supplied with feet, so that the equipment can be mounted with ease under any conditions.



A MINING HOIST DRIVEN BY A MOTOR BUILT BY THE NORTHERN ELECTRICAL MANUFACTURING COMPANY, MADISON, WIS.

Flame Arc Lamps

In an address before the Manchester section of the British Institution of Electrical Engineers, S. L. Pearce said that what the incandescent mantle has done for the gas in-

dustry it appears more than probable the flame arc lamp will finally accomplish for the electrical industry. Available figures from recent tests show that the total cost per candle power per annum of a system of street lighting using flame arcs is about 30 to 50 per cent. more economical than high-pressure gas, according to whether the arcs are long or short hour. One of the main objections to the flame arc is the fact that it does not admit of being enclosed, although efforts are being made to partially secure that end by the employment of magazines which shall contain sufficient carbons to obtain 50 hours of burning. The perfect magazine lamp has been coming for a long time; whether present-day manufacturers will meet with any better success than those who have previously attempted, is an interesting point. The outlook is distinctly promising. With a system of open arcs, the cost of currents may be taken as varying from 50 to 60 per cent. of the total charges, and the cost of the carbons, trimming, and general maintenance the remainder. With a system of "single enclosure" lamps it has been found that the cost of current is about 90 per cent. of the total, the maintenance and other charges amounting only to about 10 per cent. It is pretty evident, therefore, that any system giving long hours of burning has a great commercial value, and it is to be hoped that this may be capable of extension to "flame arcs" by the successful equipment of the magazine lamp.

Electric Pipe-Thawing Outfits

THE superiority of the electric current as a thermal agent is generally recognized and its convenience and effectiveness have led to its utilization in the thawing of water pipes, gas mains, telephone conduits and the like. It is necessary that the apparatus for such purposes shall have a range in capacity adequate to cover all ordinary requirements, shall be easy to connect and moderate in price, shall be portable and light in weight so as to be easily handled, shall be able to withstand rough usage, and shall insure protection from injury to the operator.

The Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa., has placed on the market two outfits, one for heavy service, comprising a specially designed choke coil used in connection with the primaries of a standard transformer, and one for lighter service, consisting of a transformer adapted for suitable secondary voltage adjustments, and mounted in cast-iron top and bottom frames. The heavy-duty outfit consists of a choke coil connected in series with the primary of a standard 2200-volt, 60-cycle trans-

A PIPE-THAWING TRANSFORMER BUILT BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG, PA.

former of from 15 to 25-KW. capacity. The choke coil is compactly built and enclosed in a cast-iron case which occupies a floor space of 16 by 16 inches. Five plug receptacles mounted in the upper portion of the case provide a simple means of varying the primary voltage. The various taps give approximately 50, 60, 75, 87 and 95 per cent. of the full-line voltage. By changing the positions of the plugs, any one of these combinations may be used.

The small outfit is intended for lighter service, such as thawing house piping. It is compactly built, and is enclosed in a case with cast-iron top and bottom, the transformer laminations themselves being exposed to the air, thus providing excellent conditions for cooling. Handles are provided on the top casting, enabling one man to carry the transformer, as its weight complete is approximately 100 pounds. It is intended for use on 2200-volt, 60-cycle circuits, and has a variation in secondary voltage from 55 to 35 and will maintain a current of 100 amperes for one-half hour without undue heating. No oil is used with this transformer, as the insulation is specially prepared to withstand severe conditions.

In operation the transformer should be placed as near the pipes to be thawed as possible. For dwellings, one low-tension lead may be connected to a faucet and the other to a hydrant so as to enclose the frozen section. For thawing street mains, two hydrants may be conveniently used. On account of the different conditions met with it is impossible to prescribe the exact voltage or current necessary to do any particular thawing. In general, the voltage necessary to force the same amount of current over pipes of the same diameter will vary with the length of pipe. Large pipes require less voltage to force the same current through a given length, but require more current to thaw them.

For pipes up to 5 inches in diameter, approximately 500 amperes is usually sufficient, while 12-inch mains may require 1000 amperes. As a rule, a small current for a long period of time will do the work that a large current will in a shorter time, and the thawing will be done with less chance of injury to the piping system.

A Pocket Live-Wire Indicator

A PRIZE of 500 francs was recently awarded the Minerallac Company, of Chicago, by the Association des Industriels de France, for a pocket device for use by linemen and others working where there may be live conductors, to indicate the presence of dangerous potentials on the conductors. This prize was offered by the French institution about a year ago for a device that could be used satisfactorily for the purpose mentioned.

The indicator which captured the prize consists of a glass tube, on one end of which is a metal cap carrying a strip of metal which projects some distance into the tube. To this strip of metal is fastened the indicating leaf which is made of silver. The metal cap hermetically seals the tube, which is mounted in an aluminium or wooden handle, and prevents moisture from getting inside the electroscope thus formed. If the metal cap be held near a live conductor the indicating leaf rises away from the glass tube, whereas, if it be held near a conductor on which there is no potential, the leaf lies flat against the glass. In its usual size, it will indicate positively on potentials down to 500 volts. It can be made so as to indicate lower potentials, but in this size the indicating leaf would be so light as to tear itself to pieces when

A LOCOMOTIVE CRANE BUILT BY THE BROWNING ENGINEERING COMPANY, CLEVELAND, OHIO, FOR HANDLING COAL AND ASHES

used for high-pressure conductors. It is said that those accustomed to its use can also judge approximately the potential a conductor is carrying by the distance it must be held from the conductor in order to indicate.

Locomotive Cranes for Coal Handling

SUPPLEMENTARY to what has already been printed in THE ELECTRICAL AGE for December regarding coal-handling machinery, may be mentioned another installation, illustrated herewith, in which a locomotive crane built by the Browning Engineering Company, of Cleveland, Ohio, is used.

The general arrangement of the installation is one often used in connection with locomotive cranes, and consists of a trestle built alongside the power house, with an inclined approach of not over 5 per cent. This grade can be taken without difficulty by the locomotive crane, pulling a loaded coal car. If the coal comes in bottom dumping cars it is discharged through the trestle work and piled beneath, and then properly distributed by the crane and bucket. If it comes in gondola cars, it is unloaded by the locomotive crane and grab bucket, either directly through the hatches in the boiler house into the coal bunkers or onto the stock pile. From the stock pile the coal is transferred by means of the crane and bucket to the coal bunker. Ashes are disposed of in the following way:—

Small ash cars are run in to the boiler house on a narrow-gauge track in which the ashes are conveyed or shoveled in the ordinary way. These, in turn, are pushed to a pit especially built on the outside of the boiler house, and dumped. When a sufficient amount of ashes has accumulated the ashes are taken out by means of the crane and bucket, on the trestle, and loaded into the railroad gondola cars.

In addition to the handling of coal and ashes, the locomotive crane with bucket detached may be used to do work around the yards, such as switching engines and unloading and loading machinery.

Among the special features claimed for this locomotive crane are the location of all the levers directly in front of the operator so that the machine can be handled with ease and rapidity, and the saving in labour, time, and expense used for the handling of coal and ashes. In a certain plant two men are paid $3.75 per day to unload coal and place it in a hopper by hand. Eight hours or more are required to unload a 50-ton car. With a crane, $3.75 are claimed to cover the cost of unloading two such cars in about one-eighth of the time. In large industrial plants where cars must be shifted, the crane is particularly useful, as it is equipped with 8 by 10-inch or 10 by 10-inch cylinders, developing a draw-bar pull of 11,724 or 18,289 pounds, respectively.

Mercury-Arc Rectifiers for Charging Automobile Storage Batteries

WITH the ever-increasing use of electricity for automobile propulsion, there has come a corresponding demand for a simple and convenient method of furnishing direct current for charging the storage batteries. Heretofore, aside from the steam or gasoline-driven, direct-current generator set, practically four different methods of charging have been used, namely, motor-generator sets, single-phase rotary converters, synchronous or mechanically driven rectifiers and chemical rectifiers. While all these methods have been more or less successful, they have each had inherent faults which have tended to make their operation unsatisfactory or inefficient. With these conditions in mind, the General Electric Company, of Schenectady, N. Y., developed a mercury-arc rectifier charging set, adapted to meet the requirements of automobile work. This rectifier has found wide use for this purpose on account of its compact-

ness and simplicity, as well as its high efficiency over a wide range of voltage requirements. For these reasons it is adapted for both private and public garages.

A noteworthy and interesting example of the latter is to be found in the garage about to be opened by the Cook & Stoddard Company, of Washington, D. C. This is by far the largest and most complete outfit for charging by the mercury-arc rectifier that has ever been installed.

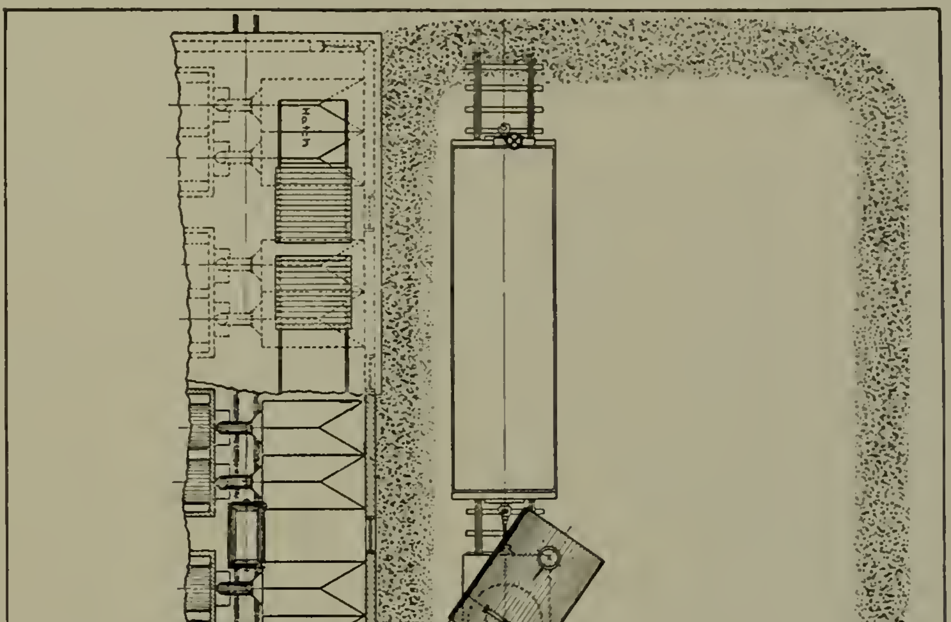
The building in which the equipment will be installed has a ground area of about 10,000 square feet, of which approximately one-third will be devoted to electric automobiles, the remainder being given over to gasoline machines. Parallel to the side wall of the building will be placed the five General Electric mercury-arc rectifiers which will form the initial installation, occupying a minimum amount of space, and at the same time being easily accessible.

Each of these five charging units will consist of a 40-ampere mercury-arc rectifier tube mounted upon a dull-black slate panel with the necessary switches, instruments and fittings grouped neatly below. The combination of terminals is such that from one to ten vehicles can be charged at one time, each vehicle being equipped with from twelve to fourteen cells, having a normal maximum charging rate of 20 amperes. Any combination of vehicles having these limiting capacities, may be charged simultaneously. It is this flexibility of arrangement used in varying and measuring the necessary voltage and current for charging purposes that makes this installation unique.

The mercury-arc rectifier tube, or transforming device, is mounted in a neat and substantial fitting so arranged that the shake, necessary to start the tube in operation, can be easily given by a pull-button on the section below. On this lower section of the panel are also mounted the instruments and switches. Three instruments are provided, two voltmeters and one ammeter. One voltmeter, having a 300-volt scale, indicates the total direct-current voltage across the direct-current terminals, while the other, a 75-volt instrument, measures the voltage across each set of batteries as they are charging. This is accomplished by means of a dial switch, the points of the switch being numbered to correspond with the charging plug terminals. The ammeter is so arranged that it will indicate the current in either of the two sets of charging terminals or in both, being provided with a flexible connector for this purpose which taps into suitable plug terminals.

The latter, as well as the charging plug terminals, are mounted on a sub-base, below the switches and instruments, in a position where they will be easily accessible for connecting. The charging plug terminals are so constructed that the circuit is not broken on the insertion or withdrawal of the plugs. They are arranged in two series of five each, these two sets of five being connected in multiple across the direct-current terminals of the rectifier tube. It is therefore evident that one set of cells, requiring a maximum charging current of 20 amperes, may be plugged in, or any combination of plugs may be used, provided the total charging current does not exceed the maximum load of the rectifier tube.

In this way it will be possible to charge from one to ten 12-cell carriages at one time, by the simple process of plugging into the terminals and adjusting the voltage by the proper switches which control the alternating-current supply. Moreover, the plug terminals are so designed that the operator can connect or disconnect any carriage at any time without breaking the circuit or stopping the charging of the remaining vehicles. The complete equipment of five units will thus permit the Cook & Stoddard Company to charge as many as fifty 12-cell electric automobiles at one time.



A COAL-STORAGE AND ASH-HANDLING SYSTEM, DESIGNED AND INSTALLED BY THE BROWNING ENGINEERING COMPANY, CLEVELAND, OHIO. SEE OPPOSITE PAGE

Reflectors for Window Lighting

PROPER light for show windows has always been a perplexing problem, usually requiring special orders for fixtures to fit the

window exactly. A reflector designed by the National X-Ray Reflector Company, of Chicago, Ill., to overcome this difficulty is shown in the annexed illustration.

This "poke bonnet" reflector, as it is called, is of a trough shape, constructed in sections, each 14 inches in length and complete in itself. These

INCANDESCENT LAMP REFLECTORS FOR WINDOW LIGHTING, MANUFACTURED BY THE NATIONAL X-RAY REFLECTOR COMPANY, CHICAGO, ILL.

units can be combined to give any desired length required, but the light from them is so great, is is claimed, that they can be erected at intervals instead of being used as a continuous trough, thus making a saving of one or more lights every 3 feet.

It is claimed for this reflector that it will give double the light with the same current, or as much light with half the current now used. Each section, being separate and independent, can be adjusted to any desired angle to throw the rays of light where they are most needed. When used in the window, they can be placed in the front, back, top or end. Where only a few are needed, each reflector may be used as a separate lighting fixture and easily in-

VIEW SHOWING THE CHARACTER OF THE DIFFUSION OF LIGHT BY THE NATIONAL X-RAY COMPANY'S REFLECTOR

stalled by anyone. The reflectors are adjustable so that any desired angle may be obtained.

While these "poke bonnets" were intended primarily for window reflectors, they have met with great favour for picture lighting and for illuminating art displays. Where a considerable number are necessary for a large window or around the sides of an art room, they are attached to 1-inch tubing, through which the wires run. This tubing is suspended from the ceiling by chain supports, or by a flange on the end, attached to the wall.

The reflector is made of heavy glass, with a spiral corrugated surface, plated with sterling silver. It is a well-known fact that sterling silver provides the highest reflective surface known, on account of its whiteness and brilliancy, far superior to mercury or German silver plating. The spiral corrugations break the rays of light, and there is absolutely no shadow thrown by the filament of the lamp.

Each "poke bonnet" section is furnished with a nickel-plated twin socket, so that two lamps of any desired candle-power may be used,—8, 16 or 32,—according to the volume of light required. The back of the "bonnet" is covered with an elastic enamel, which will not crack. The surface of the reflector can be easily washed without the slightest injury.

It is claimed that a saving of one-third the lighting expense is effected by the use of these reflectors. Four of them will light a 12-foot window with great brilliancy.

A New Telephone Transmitter

ACCORDING to United States Consul Mahin, of Nottingham, England, the British General Electric Company have devised a telephone transmitter in which the mouthpiece is absent. The receiving and transmitting apparatus is combined in a small metal case, shaped like a watch, which is held continuously to the ear both in speaking and in listening, the transmitting microphone being made so sensitive that it becomes unnecessary to concentrate the sound waves on it by the aid of any mouthpiece such as is ordinarily used. Mounted on a handle, with a speaking key, the new arrangement is exactly similar to the common combined receiver and transmitter, except that there is no mouthpiece, and the speaker, as it were, addresses himself to the world at large instead of talking into a trumpet-shaped orifice. The object in omitting the mouthpiece was to prevent any accumulation of disease germs.

Personal

Alexander C. Humphreys, president of Stevens Institute, Hoboken, N. J., has been elected a director of the Equitable Life Assurance Society.

L. B. Stillwell and John Van Vleck announce the removal of their electrical and general engineering offices to 100 Broadway, New York City.

Professor V. V. Swenson, the recently elected secretary of the American Street and Interurban Railway Association, has opened offices for that body at 60 Wall street, New York City.

Charles C. Tyler, for the past two years connected with the Allis-Chalmers Company as general superintendent, became master of works at the National Cash Register Company's plant, Dayton, Ohio, on January 1.

Mr. Robert P. Porter, of New York, former head of the United States Census Office, has been awarded a silver medal by the Society of Arts, of London, for his paper, "London Electric Railways," read at the sessions of the society held in 1904 and 1905.

John Birkinbine, the well-known engineer of Philadelphia, has been once more nominated for the presidency of the Franklin Institute, an office which he has filled for several terms. Mr. Birkinbine has given the famous old institution years of unselfish and successful labours.

Hillary C. Meissimer and Donald Campbell beg to announce that they have formed a partnership for the practice of patent and trade-mark law, with offices at 56 Pine Street, New York. For a number of years Mr. Messimer was the principal associate of the late John R. Bennett, Esq., while Mr. Campbell was associated with Edwin H. Brown, Esq.

C. H. B. Chapin recently resigned from the New York Edison Company as manager of one of the branch offices in the contract and inspection department. He has now opened an office at 1170 Broadway, New York City, and is prepared to do general consulting engineering work, making a specialty of two lines that may be of interest to the central station manager. These are the developing of up-to-date methods of selling electricity, inclusive of advertising, and contracting to test meters on the circuits of such smaller companies as do not maintain a testing department of their own.

Henry C. Ebert, assistant to the third vice-president of the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa., has resigned his position to become the president of the Cincinnati Car Company and vice-president of the Ohio Traction Company. Mr. Ebert's connection with the Westinghouse Company dates back about fifteen years. After having been promoted to the position of superintendent of construction, which he occupied for some years, he was made chief of the correspondence department, later assist-

ant to the manager of works, and lastly assistant to the third vice-president. The officers of the Westinghouse Company gave a dinner in his honour at the Hotel Schenley just before he left, and as a token of the esteem in which he had been held during his long association with the company he was presented a beautiful bronze electric stand lamp.

John F. Gilchrist has resigned his position as general contract agent of the Chicago Edison Company to become assistant to the president of the same company. Mr. Gilchrist is a good engineer as well as a good business man, and Mr. Insull, the president, will find in him a worthy helper in overseeing the details incident to the responsibilities and cares of the executive office.

Thomas A. Rickard, lately editor and part owner of "The Engineering and Mining Journal," of New York, has purchased "The Mining and Scientific Press," of San Francisco. Mr. Rickard assumed active editorship on January 1, 1906. Arthur H. Halloran, son of the former proprietor, is one of his assistants. Edgar Rickard remains as business manager.

J. G. White, head of the large engineering interests in America and England bearing his name, returned recently from England, and will spend the winter in New York. He speaks very hopefully of financial and industrial conditions in England, as well as of the important engineering projects now being carried out under White management in various parts of the world.

F. M. Farmer, of the Electrical Testing Laboratories, is now in the Westinghouse Works, at East Pittsburg, Pa., conducting acceptance tests on a large order of electrical apparatus, including two 1500-KW. generators, nine 1000-KW. transformers, rotary converters, smaller transformers, etc., for the Grand Rapids-Muskegon Water Power Electric Company, of Grand Rapids, Mich.

President Wm. H. Blood has appointed Paul Lüpke, superintendent of the Trenton division of the Public Service Corporation of New Jersey, editor of the "Question Box" for the twenty-ninth convention of the National Electric Light Association, to be held next May or June. Mr. Lüpke has been, from the first, one of the most enthusiastic admirers and close students of the "Question Box," and is a firm believer in its value to central stations. He will undoubtedly make this year's "Question Box" the equal, at least, of its predecessors.

The Power & Mining Machinery Company, of Cudahy, Wis., announce that Robert T. Lozier has been appointed district sales manager of their gas machinery department, handling American-Crossley engines, American-Crossley producers, and Loomis-Pettibone gas generators, with headquarters at 52 William Street, New York.

At the recent thirty-sixth annual meeting of the Western Society of Engineers at Chicago, the following new officers were elected:—President, Bion J. Arnold; first vice-president, W. L. Abbott; second vice-president, Andrews Allen; third vice-president, Prof. Dugald C. Jackson, of Madison, Wis.; treasurer, A. Reichmann; trustee for three years, F. H. Bainbridge. Mr. Arnold is the first electrical engineer to be elected president of the society.

Arthur Williams, chairman of the committee on public policy of the National Electric Light Association, has begun the active work of this committee by sending out a copy of the first bulletin of the "Anti-Municipal Ownership League" to every member in the association, together with the letter calling their attention to the desirability of adopting special measures for the wide-spread publicity of more correct information than is generally obtained on the subject of municipal ownership.

At a meeting of the board of directors of the Wire & Telephone Company of America, held December 8, 1905, at the company's head offices in Rome, N. Y., the following changes were made:—J. S. Dyett, of Rome, N. Y., was elected president to succeed C. F. M. Niles, of Toledo, Ohio; Oliver Shiras, of Rome, N. Y., was elected vice-president to succeed J. S. Dyett, and S. H. P. Pell, of S. H. P. Pell & Company, New York City, was elected a director.

E. R. Davenport has resigned as assistant secretary of the Edison Electric Illuminating Company, of Brooklyn, and the Kings County Electric Light and Power Company, in order to assume his new duties as sales manager of the Narragansett Electric Lighting Company, Providence, R. I. Mr. Davenport has been connected with the Brooklyn lighting interests for the past ten years, having served during that time in various capacities, among which might be mentioned, in addition to the one referred to above, that of private secretary to the late E. A. Leslie and W. W. Freeman, vice-president of the Edison Electric Illuminating Company, of Brooklyn, and the Kings County Electric Light & Power Company. His new duties at Providence will offer splendid opportunity for Mr. Davenport for the utilization of the experience which he has gained with the Brooklyn company, and his many friends in the electrical profession wish him success in his new field of endeavour.

At a meeting of the board of directors of the American Institute of Electrical Engineers on December 15, Mr. John W. Lieb, Jr., was appointed trustee to represent the Institute for a term of three years upon the board of trustees of the United Engineering Society, invested with the care and administration of the new United Engineering building. Mr. Lieb at the same time was made a representative of the Institute on the building committee. He succeeds Dr. Schuyler Skaats Wheeler, who, by reason of his recent election to the presidency of the Institute, resigns from these other bodies. The representation of the Institute, therefore, after the annual meeting of the United Engineering Society in January, will consist of Messrs. Charles F. Scott, Bion J. Arnold and John W. Lieb, Jr., who are past presidents of the Institute in the order named. Work on the building is in active progress, and it is expected to lay the corner stone early in the spring.

Obituary

Edward Atkinson, the famous publicist, economist and statistician, died suddenly December 11, of acute indigestion, at his home in Boston, aged 78 years. He was born in Brookline, Mass., and began his career in the mercantile line, became financial officer of several manufacturing companies, and in 1877 was made president of the Manufacturers' Mutual Fire Insurance Company, which he helped to organize and with which he had since then been connected in the same official capacity.

Charles T. Yerkes, the "traction magnate," well known in two hemispheres, died in New York City on December 29. Bright's disease and heart trouble are said to have been the immediate cause of death. Mr. Yerkes was a man of conspicuous business ability and accumulated a large fortune by his exploitation and management of street railway prop-

erties, principally in Chicago, but afterward in London. In recent years he devoted his energies to the building of underground railways in London. A large portion of this system is now in successful operation. Mr. Yerkes was born in Philadelphia on June 25, 1837.

An Association of Advertising Managers

By RODMAN GILDER, Secretary of the Technical Publicity Association

RODMAN GILDER
The Crocker-Wheeler Co.

THE publishers of trade and technical magazines have been organized for some years. It was not until about a year ago, however, that the advertising managers of the various manufacturing concerns who supported these magazines got together in an organization in New York City, under the name of the "Technical Publicity Association." At the time of the formation of the Trade Press Association there were probably not enough advertising managers in manufacturing establishments to form an association. The organization of the Technical Publicity Association is thus a sign of the growing importance of advertising and the increased self-respect of the men who conduct the advertising departments of manufacturing concerns.

The objects of the association, as set forth in its constitution, are "the friendly interchange of ideas; the presentation to the members and guests of discourses upon various topics bearing upon matters relating to the advertising department; and the general study of all matters pertaining to the advancement of the art of publicity."

The association is finding many fields of usefulness. At the present time, for instance, there is a committee working on the subject of circulation, and it is possible that the association will inaugurate a system of investigation which will give its members definite facts as to the circulation of the various trade and technical magazines. There is no more vital point than this in advertising, nor one which is surrounded with more opaque and shifting clouds.

The membership of the association is limited "to any man or woman filling the position of advertising manager in any concern engaged in the manufacture of machinery, or in any concern which would rightfully come under the head of an 'allied industry' "; also to those "assisting in the advertising department of any such concern." This clause in the constitution has been lived up to very strictly by the association. The resignations of two of its most valued members have been accepted because they left the companies with which they had been working and hung out their own shingles as advertising experts, giving advice upon publicity matters to various concerns.

The monthly meetings of the association are sometimes thrown open to guests, and on these occasions publishers, editors, and others interested in industrial advertising are invited to attend. At the closed meetings the members get together and talk shop.

The officers of the Technical Publicity Association are:—President, C. B. Morse, of the Ingersoll-Rand Drill Company, New York; first vice-president, H. M. Cleaver, of the Niles-Bement-Pond Company, New York; second vice-president, F. H. Gale, of the General Electric Company, Schenectady, N. Y.; secretary, Rodman Gilder, of the Crocker-Wheeler Company, Ampere, N. J.; treasurer, H. M. Davis, of the Sprague Electric Company, New York; members of executive committee, Charles N. Manfred, of the Johns-Manville Com-

C. B. MORSE
The Ingersoll-Rand Co.

H. M. CLEAVER
The Niles-Bement-Pond Co.

FRANK H. GALE
The General Electric Co.

pany, New York, and F. S. Wayne, of the Robins Conveying Belt Company, New York.

Among the other concerns represented in the association are the American Wood Working Machinery Company, New York; the Cutter Electric & Manufacturing Company, Philadelphia, Pa.; the De La Vergne Machine Company, New York; the Hall Signal Company, New York; Messrs. Hammacher, Schlemmer & Co., New York; the Holophane Glass Company, New York; the International Steam Pump Company, Harrison, N. J.; the Link Belt Engineering Company, Philadelphia, Pa.; the New York Edison Company, New York; Messrs. H. T. Paiste & Co., New York; the John A. Roebling's Sons Company, Trenton, N. J.; the Sawyer-Man Company, New York; the B. F. Sturtevant Company, Hyde Park, Mass.; the M. H. Treadwell Company, New York; the Westinghouse Companies, Pittsburg, Pa.; and the Yale & Towne Manufacturing Company, New York.

New Catalogues

As commemorative of the award secured by the Abner Doble Company, of San Francisco, at the St. Louis Exposition in 1904, the company are sending out an artistic allegorical design in photogravure, representing a figure typifying "Victory," riding a Doble tangential water-wheel. The Doble exhibit at St. Louis consisted of one of their wheels, equipped with their patented needle regulating nozzle and ellipsoidal buckets. The exhibit was an operating one, the water-wheel driving a generator which furnished power for the Intramural Railway Power Plant. This was the first time that a water-wheel, in operation and doing useful work, had ever been exhibited at a world's exposition; and that the exhibit was a meritorious one, excelling in merit its competitors, was evidenced by the Grand Prize awarded to the Abner Doble Company by the international jury of awards.

A pamphlet recently issued by the Crosby Steam Gage & Valve Company, of Boston, Mass., is devoted to a new type of indicator. One important change is the placing of the spring above the pencil mechanism to avoid any error due to heat. Another difference is in the size and shape of the piston. This is 1 square inch in area, the bearing surface being the central zone of a sphere. A medallion portrait of James Watt appears on the cover of the pamphlet.

Tangential water-wheels are illustrated and described in a new catalogue sent out by the Abner Doble Company, of San Francisco, Cal. The construction of the runners, or revolving element, is fully dealt with, the changes in design due to different conditions of service being also pointed out. Several pages are devoted to the needle regulating nozzle and the construction of the shafts, bearings, and other parts, is also described. The use of various styles of governors are illustrated and described, and the wheels are shown direct-connected to electric generators, centrifugal pumps and for a variety of other service. Safety air valves for pipe lines and a vortex baffle-plate, for use in the tail race to absorb the force of wasted water, are also described. A number of installations are illustrated and described, and tables of loss of head in pipe by friction, of circumferences and areas of circles, and of decimal equivalents are also given, with formulæ useful in considering the discharge of water through orifices.

Lamp sockets for window lighting are illustrated and described in a pamphlet recently issued by the H. T. Paiste Company, of Philadelphia. The illustrations show the use of "Fielding" receptacles for window lighting and also the details of the receptacles and fuseless rosettes. A weather-proof socket plug is also illustrated. A discount sheet accompanies the pamphlet. The company also announces in the pamphlet the opening of its Boston office at 7 Otis street, in charge of Frank Booth, who will conduct the business in connection with his work with the New York Insulated Wire Company.

A series of new bulletins issued by the General Electric Company, of Schenectady, N. Y., are devoted to 4500-volt oil-break switches, 1150 and 2300-volt alternating-current switchboard panels, slow and moderate speed belt-driven generators, governors for motor-driven air compressors, and incandescent lamps for stereopticons, projectors, headlights, and like service. The filaments for these lamps are wound in a conical spiral form for lamps up to 50 candle-power, normal rating, and in cylindrical form for lamps of 100 candle-power. Other literature sent out includes a catalogue of parts of automatic circuit breakers, a folder

H. M. DAVIS
The Sprague Electric Co.

C. M. MANFRED
The Johns-Manville Co.

F. S. WAYNE
The Robins Conveying Belt Co.

describing the "Electrotherm," the electrical substitute for the hot water bottle, a folder describing decorative lighting outfits, a price list of Thomson recording wattmeters, and a blotter illustrating assembled commutator segments.

Steel crane motors, built by the Northern Electrical Manufacturing Company, of Madison, Wis., are illustrated and described in a bulletin recently issued. The field frames are of soft cast steel, the armature shafts are of large diameter, and the motor is enclosed in a dust-proof frame, an opening above the commutator permitting easy access to the brushes. These and other features of construction are fully illustrated and described. The use of Northern motors for a variety of service is also illustrated.

Stationary and portable motor-driven air compressors are dealt with in a bulletin recently sent out by the National Electric Company, of Milwaukee, Wis. The machines are of very compact form; the portable set includes two reservoir tanks mounted with the compressor on a substantial truck. Another bulletin is devoted to polyphase induction motors, with "squirrel-cage" rotors. An autostarter, to reduce the starting current, is also illustrated and described.

A folder recently sent out by the General Electric Company contains some excellent illustrations of the lighting effects obtained with light-balancing, selective diffuser ceilings and concentric diffusers used with arc lamps. An attractive pamphlet is devoted to varnished cambric cables, and other literature includes a catalogue of parts for direct-current, enclosed-arc lamps, circulars on knife switches, double push-button pocket switches, and blotters illustrating field coils and pole-line oil switches.

Alternating-current generators built by the Allis-Chalmers Co., of Milwaukee, Wis., are illustrated and described in a bulletin recently issued. The machines are built in two styles. With the engine type, the engine fly-wheel is mounted on the shaft alongside the generator; in the fly-wheel type, the field poles are mounted on the face of the fly-wheel, which thus serves the double purpose of fly-wheel and field spider. Oil-insulated transformers are illustrated and described in a pamphlet recently issued. The illustrations give an excellent idea of how the transformers are put together. Curves are also given showing the results of temperature, efficiency and regulation tests. Another bulletin is devoted to multiple motors and generators. Illustrations show these machines in a variety of service.

In the "souvenir" programme issued for the recent opening week of the new Majestic Theatre in Chicago, appears the following item:—"The electric light and power equipment in the Majestic Theatre Building is one of the best and most modern private plants of its kind in the city. It was built and installed by the Allis-Chalmers Company, of Milwaukee, and consists of three generating units composed of Reynolds-Corliss engines of the Reliance type, direct-connected to Bullock direct-current generators. Two of the engines are 20-inch by 26-inch, producing 300 H. P. each; the third is 16-inch by 30-inch, and of 150-H. P. The two larger engines are each connected to a Bullock direct-current generator of 200-KW. capacity, while the smaller is coupled with a 100-KW. generator of the same make. There are two compensating sets, each consisting of a Bullock 45-KW. generator and a 15-KW. machine. This plant produces a 220-volt power current and a 110-volt lighting current, distributed by the three-wire system through a seven-panel switchboard. The power is used for running the elevators, scene shifting machinery, compressed-air plant, ventilating plant, etc., and furnishes the lighting current for all the building and the theatre illumination."

The wireless telegraph system of the Clark Electrical Engineering Company, of Detroit, Mich., is briefly described in a booklet recently issued. The apparatus is illustrated, together with a miniature demonstrating set and an outfit for field use.

Stationary tubular boilers are illustrated and described in a bulletin recently sent out by the Chandler & Taylor Company, of Indianapolis, Ind. Another bulletin is devoted to plain slide-valve engines, the various details being illustrated and described. The half-tones are excellent and both pamphlets are of a high order typographically.

The generating and distributing system of the Portland General Electric Company, of Portland, Ore., was described by F. G. Sykes before the electrical transmission section of the Pacific Coast Engineering Congress at the Lewis & Clark Centennial Exposition at Portland in June, 1905, and the company has sent out a pamphlet containing a reprint of the paper. It gives a full illustrated description of the several stations and their equipment.

Grab buckets built by the Browning Engineering Co., of Cleveland, Ohio, are illustrated and described in two bulletins recently issued. They are shown in use with locomotive cranes, telpherage systems, and travelling cranes for a variety of work, such as digging ashes, coal, city refuse, crushed stone, grain, ore, slag, sawdust, and other similar material.

Control apparatus and trolleys for single-phase railway systems are illustrated and described in a pamphlet recently sent out by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa. Diagrams show the arrangement of apparatus for hand control and for the unit switch system of multiple control. Trolleys of the pantagraph and of the bow type are illustrated and described, as is also the single and double catenary line construction. Automatic circuit-breakers with carbon break are dealt with in another bulletin illustrating and describing the various types. A neat little pamphlet is devoted to pipe-thawing outfits. A table gives the results of actual thawing operations under varying conditions.

The Green Fuel Economizer Company, of Matteawan, N. Y., have issued a neat little circular in the interest of their steel-plate fans, blowers, and exhausters. A variety of types are shown, and particulars of them are given, including tables of sizes and capacities. In the minds of most engineers, the Green Fuel Economizer Company is associated purely with their well-known economizer, and the fact that they make other things besides is apt to be forgotten; hence this little pamphlet will serve as a useful reminder of them.

Multiphase induction integrating wattmeters are illustrated and described in a bulletin recently sent out by the Fort Wayne Electric Works, of Fort Wayne, Ind. Other bulletine issued deal with small power motors and single-phase induction motors. The former are built for direct current in sizes up to 1½ H. P. and for alternating current in sizes up to 1-30 H. P. The single-phase motors are made in sizes up to 15 H. P. Multiphase induction motors are dealt with in a pamphlet. The starting compensator used is also illustrated and described, and diagrams show the arrangement of wires for the outfit.

The Hunt automatic railway, for conveying the coal from the front of a wharf to the storage bin, the car returning automatically to the starting point, is illustrated and described in a booklet recently sent out by the C. W. Hunt Company, of West New Brighton, Staten Island, N. Y. Many illustrations are given of installations of the railway in power stations, coal yards and like places. Another pamphlet illustrates the company's general line of machinery, including steeple and parabolic boom towers, conveyors, steam and electric hoisting engines, cable railways, and storage battery locomotives.

The Wallace Barnes Company, of Bristol, Conn., manufacturers of small springs of every description, have sent out an attractively gotten up four-page circular calling attention to their different kinds of washers. A page of illustrations of sample washers is given, and these admirably exemplify the variety of washers made by them and their facilities for that kind of work. Their equipment enables them to furnish washers from 3-16 inches in diameter and 1-100 of an inch thick up to 3 inches in diameter and $\frac{1}{8}$ of an inch thick. A washer, generally speaking, is so simple a thing, that one is not quite prepared for the rather remarkable collection of these little devices shown in the circular.

Trade News

The Westinghouse Electric & Manufacturing Company are doing a large business in equipping mines with electric locomotives, to replace the older forms of haulage, whether animal or mechanical. A recent contract closed by the Westinghouse Company is one with the Newport Mining Company, who have decided to equip their mines at Ironton, Mich., with both surface and underground electric haulage. They will use electric locomotives the year around in the various levels underground for bringing the ore to the bottom of the shaft, and after the transportation season has closed will use electric locomotives on the surface for hauling ore from the top of the shaft to the various stock piles for storage. For these purposes they have ordered six 4-ton Westinghouse mine locomotives. Electrical apparatus for the equipment of the necessary power station will also be provided by the Westinghouse Company, consisting of a 150-KW., 250-volt generator, direct-connected to a Corliss engine of 130 revolutions per minute, and a 3-panel switchboard, besides other auxiliary apparatus. The company are finding an extensive field for their motor equipments in the marble finishing industry. They lately completed the equipment of a large marble yard in the South. The operation of this plant by means of electric drive has been eminently satisfactory, resulting in a marked increase in the product and a decrease in the operating cost. The electrification of the plant has further eliminated the many objectionable features of belting and shafting, which were very much in evidence under the old conditions. The company also have recently renewed an annual contract covering the requirements of the Moline Elevator Company, Moline, Ill., so far as their motor needs are concerned. The renewing of this contract is due to the highly satisfactory performance of Westinghouse elevator motors under the most trying conditions.

The American Stoker Company, of Erie, Pa., has acquired from the McMyler Manufacturing Company, of Cleveland, Ohio, the patterns, drawings, patents and good will for the manufacture of the "Victor" chain grate stoker. Mr. F. Girtanner, the designer of the stoker, has entered the employ of the American Stoker Company. The stoker will hereafter be known as the "American" chain grate stoker, and will be produced concurrently with the company's underfeed stoker.

C. R. Underhill, Electromagnet Specialist, 55 Liberty Street, New York, has issued a new illustrated catalogue, showing the various types of plunger electromagnets, solenoids and other coils designed and supplied by him, and he has also revised and published a new edition of his booklet, "Facts About Electromagnets." This gives much information regarding electromagnets and solenoids, and contains a very interesting table for magnet windings. Both the catalogue and booklet will be sent free to any address, upon request.

The Standard Roller Bearing Company, of Philadelphia, Pa., has just started the erection of a brass and iron foundry 60 by 125 feet, two stories in height. Their crucible steel casting plant started in operation a few weeks ago, the size of this building being 60 by 95 feet.

The rights to build Parsons marine turbines in the United States are held by the Allis-Chalmers Company, of Milwaukee, Chicago, Cincinnati, and Scranton; Wm. Cramp & Sons, Philadelphia; W. A. Fletcher Company, Hoboken, N. J.; the Quintard Iron Works, New York, and the Bath Iron Works, of Bath, Me. The Allis-Chalmers Company are not only licensees under the Parsons marine turbine patents, but they also hold the rights for manufacturing the Parsons turbine blowers and compressors, and have recently formed an alliance with the Honourable Chas. A. Parsons, the turbine inventor, for a full co-operation and interchange of data on steam turbines for land operations. They are at the present time practically doubling their immense plant at West Allis, Milwaukee, Wis., the greater part of the new shops being intended for an extension of their steam turbine work and the electric generators to be driven by turbines. They will, at their West Allis Works, build marine steam turbines for the Great Lakes and for the Pacific Coast, and both there and at their Scranton Works will build marine turbines for the Atlantic trade.

J. P. Hornaday & Company, of Cincinnati, Ohio, have established an operating department for the purpose of taking up and developing street railways, waterworks, electric light plants, artificial and natural gas properties, rebuilding, reorganizing and financing them. They are making a specialty of financing the class of smaller steam railroads, and will also purchase properties and operate them, paying special attention to those in need of reorganization.

The Oswego Boiler Works, at Oswego, N. Y., have been purchased by New York people understood to be associated with the A. D. Granger Company, the machinery house at 95 Liberty street, New York, with branches at Philadelphia and Pittsburg. The plant, which occupies about 20 acres of ground, was established twelve years ago, and it is expected will be placed in active operation at once. Steel plate work in all branches, including boilers, tanks, and stacks, will be manufactured. The new company will be known as the Oswego Boiler & Engine Company, with the main office at Oswego, N. Y.

The Standard Underground Cable Company has leased the exclusive use of an all copper line to connect its general offices and the factories at Pittsburg, branch offices at New York and Philadelphia, and its Eastern factories at Perth Amboy. This private line will be available for either telegraph or telephone serv-

ice. There could be no better evidence of the large aggregate volume of business and the growing condition of the company, for so far as known this will be the longest exclusive wire owned or operated by any company confining itself to the manufacture of copper wire and cables. This service was in effect January 1, 1906, and while without doubt of great convenience and value to the company in facilitating communication between its offices and factories and the important market centers of New York, Philadelphia, and Pittsburg, it was installed primarily to enable it to place itself in closer touch with its customers and to give these customers the same quick service that would be possible if its general offices were located in each of these cities, instead of in one.

The National Carbon Company, of Cleveland, Ohio, recently obtained an injunction restraining the Columbia Dry Battery Company and the Vim Company, both of Chicago, from making and selling a cheap dry battery and using the trade-mark "Columbia," which is the property of the National Carbon Company, to assist the sale. Suit was brought before Judge Kohlsaat, in Chicago, with the result that on December 12, an injunction was issued against them forbidding them from offering for sale any dry batteries not made by the National Carbon Company to which is applied the word "Columbia" or the words "Columbia Dry Battery Company." The effect of this injunction is to confirm the National Carbon Company in the possession of the trade-mark "Columbia."

The J. G. Brill Company, car and truck builders, of Philadelphia, are shipping fifty gondola cars to the "Tramway Rural a Vapour," at Buenos-Aires. This is a duplicate of an order of a year ago. The railway company operates lines within the city of Buenos-Aires and recently electrified its system. It also has a steam line running out of the city. The Brill Company is building at present seventy-five of its semi-convertible type of car for the city lines, and a fine dining car for the steam road. Practically all of the equipment of the Tramway Rural has been furnished by the Philadelphia firm.

It is reported that Poplar Borough, a suburb of London, is about to install an electrochemical plant for the manufacture of disinfectants for washing streets, flushing sewers, and for general use by the health board.

The General Electric Company's Exhibit at the Chicago Electrical Show

THE educational features of the Chicago Electrical Show are most completely carried out by the exhibit of the General Electric Company, which in general is made up of those things of most interest to householders.

A large space is devoted to devices for heating and cooking by electricity. These include electric flat irons, coffee percolators, frying pans, small water heaters, etc., all of which are in constant service. To prove the durability of the different devices, some of them are operated continuously without water, in this way showing their practical indestructibility from accidental causes. In addition to the line of cooking devices mentioned, electric ovens are exhibited, and at certain hours of the day biscuits are baked and distributed to visitors. A novelty which promises to become popular is the electric corn popper, there shown for the first time.

Other electrically operated household conveniences shown include sewing machine, grinding, drilling, and buffing motors. Electric fans of various kinds, including ventilating outfits for the kitchen, are also exhibited. A special section is devoted to cigar lighters of both the desk and pendant types.

One of the unique features in the eyes of the layman, is the mercury-arc rectifier. The General Electric Company has supplied so many of these for charging batteries in automobile garages, both private and public, that their importance in the automobile field is well established.

A recording wattmeter is shown in operation, so that visitors may turn on or off various lights and witness the change in the speed of the meter, as well as a prepayment meter, which can be started by inserting metal tokens, thus illustrating its method of operation.

An electric hoist in full operation offers another attraction of educational interest. This, combined with quite a variety of small motors of different types, is of value to proprietors of small shops of all kinds, as well as to the man who has a small laboratory in his own house.

Not the least interesting portion of the exhibit is found in the moving pictures. These show, among other views, the race between the celebrated electric locomotive built by the American Locomotive Company for the New York Central Railroad and a steam train. The electric locomotive has repeatedly beaten the fastest and most powerful steam locomotive of the New York Central lines, and the moving pictures as shown were taken of a typical race in which electricity won easily.

The entire exhibit is lighted by enclosed arc lamps with concentric diffusers and the new G. E. M. lamps which consume only $2\frac{1}{2}$ watts per candle-power. They are furnished in three sizes, rated as 125, 187, and 250 watts.

An attractive reception space opposite the entrance of the show is an inviting feature and makes a most convenient meeting place for visitors.

Electric Motors in Argentina

WRITING under recent date from Buenos Ayres, Special Agent Hutchinson, of the Department of Commerce and Labour, says that there is a demand in Argentina for motors of all kinds, from electric fan motors up to 4 or 5-H. P. gasoline engines for use on the "estancias." In the towns there is steadily increasing use of electric power for small industries.

Not only is Buenos Ayres well supplied with electric service, but many of the interior towns have their electric lighting plants, and wherever persistent efforts have been made to introduce small motors, they have met with success.

The Germans are, as a rule, particularly active in the matter, and there are many recent instances in which their goods have been pushed so energetically in new fields as almost to exclude the American. The moment a concession is made for the erection of an electric plant in a new place, German agents are to be found on the spot getting contracts for the installation of motors, thus gaining the advantage which comes from being first in possession of the field.

There are openings at present at many interior points, notably, Rosario, Santa Fe, Parana, Concordia and Corrientes.

At the last-named town an electric plant is now in process of construction and will be completed in a few months. It is being built by a German company.

A single-phase system is being installed by the General Electric Company on a branch line of the Toledo & Chicago Interurban Railway Company in Indiana. The line extends 50 miles from Fort Wayne to Kendallville.

Artificial Illumination.—VIII

By DR. EDWIN JAMES HOUSTON

INTERIOR ILLUMINATION

SO far as daylight values are concerned, the interior illumination of buildings from natural sources is always more satisfactory than can be obtained by the aid of any artificial illumination. This is not, however, necessarily the case so far as the amount of light, i. e., the intensity of the illumination, is concerned; for, unless the rooms are situated in the front of the building, with a good exposure to the sun, the intensity of illumination may be smaller than that which would be produced by artificial lighting. Even where the exposure is good, it is only during certain hours of the day that the daylight illumination is at its best.

As regards inside rooms, however, the character of the daylight illumination is never so satisfactory as that obtained by artificial illumination. This may be true even during the brightest hours of the day, when the amount of light is sadly deficient, so that artificial illumination is necessarily resorted to, while in some rooms there are very few hours of the day when artificial illumination is not an absolute necessity.

The highest type of interior illumination is that which approaches most closely the illumination of ordinary daylight. The ideal artificial illumination would be one of such a character that, as the intensity of the daylight gradually wanes, sufficient artificial light is supplied to maintain as nearly as possible an intensity produced during the brightest hours of the day. An illumination of this character would necessarily result in the gradual merging of the illumination produced by daylight into that produced by artificial light. As the daylight gradually decreases, the artificial sources of light are made to furnish gradually increasing amounts of light, so as to maintain as nearly as possible the same intensity of illumination. In order best to obtain this result, the daylight values of the artificial light should not vary greatly from those of ordinary sunlight.

Let us suppose, for example, that the room to be illumined, in the ideal manner, is provided with a high ceiling, and has its daylight admitted by means of a skylight, placed directly over the middle of the room, and so proportioned as to size that the proper amount of daylight to ensure a comfortable illumination is permitted to enter the room from above. Assuming the ceiling to be at a proper height from the floor, an ideal character of lighting would be ensured, since to one coming into the room there would be no unpleasant luminous sources to weary the eyes or to decrease the sensitiveness of the retina. Such a room would present merely a uniform area of illumination situated at such a distance above the floor as to render it improbable that the light would cause annoyance by entering the eye of the observer directly.

Under these circumstances, as the daylight gradually wanes, there might be automatically introduced a sufficient number of incandescent electric lamps, or other artificial sources of light to maintain uniform the brilliancy of the skylight. Hence, provided the daylight values of the artificial lights were sufficiently near those of sunlight, it would be impossible to note, so far as one in the room was concerned, any change taking place in the character of the illumination. If, therefore, as the amount of daylight gradually decreases, the amount of artificial light gradually increases; the intensity of the illumination would be maintained uniform, even when the entire daylight disappeared on the setting in of the night. Artificial illumination of this character would leave practically nothing to be desired.

Where the matter of expense can be left out of consideration, it is evident that there are no scientific reasons why the artificial illumination of great halls and rooms generally, situated so as to present their ceilings to the sky, should not be made in all respects as good as that of the best daylight illumination. In order to ensure this, it would, of course, be necessary that the artificial illumination should agree with natural daylight illumination in the following respects:—

1.—As regards the intensity of its illumination.

2.—As regards the character of its distribution.

3.—As regards the daylight values of the artificial light.

4.—As regards the freedom of the artificial light from low heat rays and injurious products of combustion.

From a structural standpoint, in order to ensure the high type of illumination above referred to, the following conditions are essential:—

1.—That the architect in planning the building should plan it with definite ideas as to the manner in which it is to receive its artificial illumination.

2.—That the decoration of the building be such as to aid, and not to hinder, the proper distribution both of daylight and of artificial light. In other words, the character of the decoration should be such as to permit the artificial light to resemble daylight as regards its general diffusion, i. e., in the absence of regions where variations exist in the intensity of the illumination, the entire room space being lighted by a uniform intensity of light.

3.—That the electric illumination expert should so plan the character of the lights employed as to produce daylight values for all the rooms, not only as regards the intensity of the illumination, but also as regards its daylight values. Further, in the ideal case above supposed,—i. e., in which the room is illumined by means of light entering a centrally located skylight,—that some contrivance be made, preferably automatic, though readily regulable by the hand, as will supply the necessary amount of artificial light to maintain uniform the general illumination of the skylight, and, therefore, of the room, as the daylight gradually wanes. Moreover, to so select such types of artificial luminous sources as will result in the production of a light, the daylight values of which shall not differ greatly from that of the sun.

So far as the first condition is concerned, i. e., the architectural planning of the building, it unfortunately seldom happens that it is possible, except in very rare cases, to employ a central skylight illumination for the daylight and artificial illumination of the rooms, except those at the top of the buildings. Space is too costly in most cases to permit such a thing as the erection of a single-story build-

FIGS. 1 AND 2.—THE MAIN FLOOR OF THE SHOP AND MANUFACTORY OF JACOB REED'S SONS, PHILADELPHIA. THE BUILDING IS OF REINFORCED CONCRETE AND IS LIGHTED BY A SHAFT ON EACH SIDE. SKYLIGHTS AT THE BOTTOM OF THE LIGHT WELLS FORM THE CEILING FOR THE SPACES ON EACH SIDE OF THE CENTRAL PART OF THE MAIN FLOOR

ing. On the contrary, the requirements of the densely built up sections of our large cities not only prohibit such waste spaces, but even require the erection of the modern "sky-scrapers," with, in many cases, the inside rooms so located that their proper lighting by daylight is not only a matter of great difficulty, but sometimes an impossibility.

It is, unfortunately, too often the case that the architect pays more attention to the appearance of the building from the outside, that is, as regards its architectural lines, than to the inside. Too frequently, the outer walls of the building are so designed to meet supposed architectural requirements as to prevent the entrance of sufficient light to properly illumine some of the interiors, in this manner rendering many of the rooms, that should be among the best lighted by daylight, almost entirely cut out from efficient illumination by the introduction of some creation of imaginary architectural beauty, or some imposing lines of façades.

Where building lots are expensive, and this, as a rule, is generally the case in the central parts of large cities where buildings of the finer type of architectural construction are most apt to be situated, it is, perhaps, natural and certainly proper to economize the floor space as far as possible, so that the interior rooms are often necessarily limited so far as the direct entrance of daylight is concerned.

In such buildings, the presence of properly proportioned light wells remedies this defect to a certain extent, but in many cases the dimensions of the light wells are too seriously contracted to be of much value.

Coming now to the second requirement of artificial illumination for interiors, i. e., the character of the decoration, we will find in this a matter of the greatest importance. Even when the character of the artificial illuminant selected is such as will permit it to closely resemble daylight in both intensity and daylight colour values, as well as in the absence of excessive heat radiation and the evolution of noxious gases, yet, unless the character of the decoration is such as will permit the distribution of the light to be a true surface illumination, free from marked contrasts of light and shade, then the illumination will fail to be satisfactory within any ordinary limits of practical use of light sources; for, in order to obtain a proper surface illumination, the walls, ceilings and hangings of the room should be of such a character as to readily act as secondary luminous sources, diffusing the light in all directions, and thus absolutely preventing the formation of shadows. This would be true despite the best efforts of the architect to ensure good daylight illumination as well as to provide suitable spaces in which the illumination expert may place the sources of artificial light.

For the proper illumination of an interior, it is, therefore, necessary that the decorator should use good judgment as regards the character of the decoration of the rooms. He should never lose sight of the fact that the character of the illumination will frequently determine the character of the decoration which can satisfactorily be placed in a given room. In other words, he should endeavour intelligently, where certain effects are desired, to ascertain whether the ordinary daylight illumination of the room, or the character of the artificial illumination with which it is to be provided, will permit such use. It will be interesting, therefore, to discuss briefly some of the common errors that are made in the interior decoration of a building.

In making these remarks the author is not unmindful of the fact that the work of the interior decorator should not be ruthlessly restricted by unnecessary objections on the part of either the illuminating engineer or the architect, recognizing, as he does, the importance of harmonious and beautiful surroundings. It is, however, a questionable matter whether, in any case, so-called decorations, of such a nature as will not permit a proper lighting of rooms, can be regarded as possessing any true artistic value.

Some of the principal errors that are to be found in the interior decoration of rooms are:—

1.—The use of highly polished surfaces, such, for example, as hard wood, especially when varnished; the use of enamelled walls, porcelain coverings, glass mirror panels, highly polished marbles or granites. While all of these are capable of producing many beautiful effects, yet they frequently render the proper illumination of the room a matter of considerable difficulty, owing to the fact that their presence makes it almost impossible to obtain that uniformity in the intensity of the illumination which is so necessary to rest the eye. Of course, in the case of a ball room or a salon, where it is especially desired to produce a

great brilliancy in the illumination, such interior decorative effects lend themselves admirably to such purposes. In these cases, however, the amount of light in candle feet per unit of area, must be far greater than usual, since the rooms, if insufficiently supplied with the number of separate units of illumination, would exhibit a spotty illumination, characterized by comparatively small, highly illumined areas, followed by sharp contrasts.

2.—Employing surfaces that are highly absorbant, so that they throw off or diffuse a very small percentage of the light incident on their surfaces. This character of decoration is to be found in all rough surfaces, the colours of which contain too small a percentage of white light. Such surfaces are to be found in most very dark coloured substances, as dark-red velvets, wall papers, or extremely dark crimson papers or hangings. Dark blues, purples, and dark greens are even more objectionable. Coloured surfaces of this character absorb nearly all the light that is incident on their faces, so that a room, a large portion of the surface of which is decorated with these materials, cannot be uniformly lighted by artificial sources of light unless their number is exceedingly great; for, otherwise the parts of the room lying between contiguous lamps in order to be uniformly illumined must receive light by secondary radiation from other portions of the room, and this the character of the decoration prevents. In other words, in such a room the number of lights must be sufficiently great as to so directly illumine the space between contiguous lamps, as to prevent a uniformly illumined field to the eye.

Take, for example, the case of a room the ceiling of which is finished in dark century oak, often purposely darkened to an extent greater than that found in most cases of such wood. Let us suppose that the walls of the room are finished with dark red or purple paper, and that the floor is covered with dark coloured rugs, the wood being stained dark where left uncovered. Unless the hangings or the furniture in the room are of such colours and materials as permit the ready diffusion of light, the room will necessarily present considerable difficulties for proper illumination by either daylight or artificial light, since all objects in the room must receive their illumination almost entirely by direct radiation from the luminous source.

The writer has in mind a very beautiful church building, situated in Philadelphia, the lighting of which is obtained almost entirely from windows on the sides of the church. These windows are placed both under a comparatively low portion of the building extending parallel to the two sides of the main vaulted body of the church, as well as on the side of the walls of the main vaulted body of the building. Here the entrance of daylight required for illumination is practically limited to the light that can get in at the side windows. The main space of the church also receives light from four large windows placed at the ends of the building. This light, however, is, to a great extent, absorbed by the dark dull oak, blackened so as to resemble century oak, that forms the ceiling of all parts of the building. It is interesting, in connection with this, to remark that although this church building is provided with an excellent system of artificial illumination so far as the position of the lamps is concerned, the lamps being placed out of the view of the eye on the side of the roof beams facing the chancel of the church, this being an Episcopal Church, yet, although about 525 sixteen candle-power incandescent electric lamps, of approximately 8000 candle-power, are employed for lighting the building, perceptible shadows can be seen against the dark roof, being cast by the wooden beams, thus greatly lessenening the architectural effect of a very beautiful structure.

In such a system of lighting, under the bad influence of the character of the decoration, all the artificial light that reaches the pews as may be necessary for the purpose of reading comes directly from the incandescent lights. Even the character of the pews, formed as they are of blackened oak, is such that little or no help is afforded by diffusion from their surfaces. It is, however, very noticeable that the hymnals and prayer books were placed with their white ends showing above the wooden rack on the back of the pews, and offering, as they did, an admirable diffusing surface for throwing the light received from the lamps above, caused the production of disagreeable spots of light on the polished wooden backs of the pews.

The writer noticed also in this church that the walls had been left undecorated with a variety of white hard sand finish. This colour of wall unquestionably served to a considerable extent to aid in throwing some of the light received from the sources near the ceiling downwards onto the floor, thus improving the uniformity of the illumination. The writer believes it is the intention of the church authorities to decorate the entire building. If, therefore, the character of the decoration to be employed should be that which is so common in churches, i. e., some sombre, dark-coloured surface, the difficulties of lighting the church building will be still greater. Fortunately, the amount of artificial light employed in this church is such that, with the exception of the dark shadows above referred to, the amount of light received in the pews is sufficient for comfortable reading, even when only a portion of the lights are employed. It would seem, however, more than probable, that unless judgment is employed in the selection of proper decorative tints and the character of the surface employed for the decoration,

FIG. 3.—THE MAIN FLOOR OF THE REED BUILDING ON THE EAST SIDE. THE SIDE SKYLIGHTS ADMIT THE LIGHT FOR THE ILLUMINATION OF THE CENTRAL PART OF THE FLOOR

that it will be found necessary to employ all the lights, and that even then the illumination will be unsatisfactory.

As regards the third requirement, i. e., the daylight values of the source of light, it is questionable whether there is any artificial illuminant suitable for the lighting of interiors that can produce light whose daylight values closely resemble those of ordinary sunlight, at least so far as would be necessary in order to permit the lighting to gradually take the place of ordinary daylight in the case of the ideal artificial illumination above referred to. There should, however, be no difficulty in obtaining a general light of this character by the proper intermixture of such luminous sources as electric arc lights with ordinary incandescent electric lamps, and this especially, if the electric arc lamps employed are so covered with an opalescent shade to prevent the presence of too great a proportion of the blue rays, these different sources of light being so proportioned as to ensure the correct percentage of the physiologically active rays that exist in ordinary sunlight between the reds and violets of the spectrum.

An example of an approach to the perfect type of lighting above described, in which the gradual introduction of artificial light is so arranged that as the daylight gradually fades it is imperceptibly replaced by the artificial light, will be found in the illumination of the United States Capitol Building, at Washington, D. C. Here both the Senate chamber and that of the House of Representatives are lighted by means of suitably-arranged skylights that permit such a passage of daylight from the skylight overhead as to thoroughly but comfortably illumine them. Back of the skylight, artificial sources of illumination are placed, so that as the daylight gradually wanes, a gradual increasing number of luminous sources are introduced, so that with the exception of a slight difference in colour values, one would not be apt to notice that the natural light of day had gradually been replaced by the electric light.

It most generally happens, however, that it is impracticable to sacrifice the valuable space necessary to obtain lighting by means of skylights, and yet, under such circumstances, it is possible to obtain a very efficient type of artificial illumination in another way. Take, for example, the most difficult, but what is perhaps the most common case as regards the situation of the building that is to be lighted, i. e., where it is situated somewhere within a block, and is surrounded on each side by high buildings. Here, on account of the high price of the land, there is quite naturally considerable hesitation towards appropriating much space for the accommodation of a light well or of skylights; for, since such buildings are frequently from twelve to fifteen, or even a greater number of stories, in height, a considerable amount of floor space would necessarily be sacrificed in this manner. In all such buildings, however, where the light well is made of too small dimensions, the daylight lighting of the interior rooms will necessarily be unsatisfactory.

It will be interesting, in connection with the above type of lighting, to note a plan that has been successfully tried in Philadelphia at the shop and manufactory of Jacob Reed's Sons. This building is constructed of reinforced concrete. The building lot has a 50-foot front and is 230 feet in depth. The plan of the building is such that on the ground floor the area of the entire lot is utilized for the salesrooms and showrooms. As shown in Fig. 1, these consist of a long room provided with an arched central ceiling, the ends of the arch resting on two rows of large cement columns that are provided for the support of the side walls of the upper stories. In this manner there are provided two light and ventilating shafts, 10 feet in width and 130 feet in length. The light wells are not extended the entire length of the lot. An extensive area at the front is left for the erection of a high vaulted portion containing about 51 feet of glass front, together with about 11 feet of columns. A part of the rear is similarly constructed, so that neither the front or back require side lighting near the large windows that are employed in those parts of the building.

Skylights are placed along the bottom of the light shaft, so as to form a ceiling for the space between the column and the side wall, as shown in Fig. 2. The space above the columns is provided with semi-circular windows. In this manner an exceedingly satisfactory daylight illumination is ensured, no artificial light being required during the ordinary daylight business hours, except during the short days of winter.

For the artificial illumination, two 2000 nominal candle-power enclosed-arc lamps are placed in each of the spaces that lie between two contiguous windows, one near the skylight, to throw its light downwards through the skylight into the space between the side walls and the rows of columns, and the other at an elevation, for the purpose of throwing its light through the windows into the main part of the room. Each of these arc lights is provided with reflectors so as to throw the light in the desired direction. They are also provided with clear glass inner globes.

No attempt has been made to obtain daylight values with artificial light, since the arc lights employed to give colour value in which the departure from ordinary daylight values is not very marked.

Fig. 3 shows the general appearance of the side skylights. It is interesting to note that the above plan produces very satisfactory light for the display of goods. These goods, for the greater part, consist of black or dark-coloured cloths, such as commonly employed for suitings, so that a large amount of light is required for their proper display

It must not be supposed from what has been said in the foregoing that the subject of interior illumination is of such a nature as to permit it to be described under any one general head. What has been referred to concerns only a comparatively limited branch of the subject,—the illumination, both natural and artificial, of the interior of such areas as are to be found in large assembly halls, in parlours, and like places. On the contrary, the subject of interior illumination necessarily covers not only as great a variety of fields as there are different types of buildings to be illumined, but also the different character of the work that is carried on in such buildings.

It needs no argument to prove that the character of the illumination of a ballroom necessarily differs from that required for the illumination of a bank or a trust company, or, that the type of light suitable for a church would be unsuitable for a theatre; for, in each type of building, the interior of which is to be lighted, there must necessarily be an accordance between the amount and general character of the artificial illumination required for the peculiar character of the work that is to be carried on.

Take, for example, the case of a department store. The general character of the illumination that would be suitable, generally speaking, for the interior, would evidently differ markedly from that required for a workshop. Nor is it true that in either of these buildings it is possible to employ the same type of illumination throughout all its parts, since the illumination of some parts of the building would necessarily vary with its particular character of the goods displayed. For example, in a department store in the rooms intended for

the display of dress goods, where, from the situation of the room, artificial illumination is required during the ordinary daylight hours, the particular character of the illumination required would not only differ in this room from that employed elsewhere, but, what is very important, the general character of the light employed would vary with the type of dress goods that are to be displayed. To illustrate, if these are intended to be worn during daylight hours, then only an artificial illuminant possessing true daylight values would be suitable.

On the contrary, if such dress goods are to be employed for the ballroom, then necessarily the character of the light must be that employed in the ballroom, otherwise the true colours will not be shown. Here again an accordance must necessarily exist between the character of the artificial light employed for the display of the goods, and that which is to be employed in the ballroom where they are intended to be used; for, if the ballroom is to be lighted by 16-candle-power incandescent lamps of a given efficiency, or in other words, a given temperature, and consequently a greater colour value, satisfactory results will be obtained only when similar incandescent lights are employed in the show room. In a similar manner, if arc lighting is employed, then only arc lights would be satisfactory for such display.

In work-shop illumination also, the amount of light will of course vary with the character of the work done. A machine shop requires, generally speaking, a light that is thrown mainly on either the machine or the work. There are, however, types of work shops where such an illumination would be far from satisfactory. It will, therefore, be necessary, in order to properly treat of the subject of interior illumination, to divide it into a number of different classes, so as to be able to discuss the peculiar needs of each class of illumination, as well as to point out the ways in which such requirements can be best obtained.

Some of the principal classes into which, for the sake of convenience, interior illumination can be divided, are:—

1.—Department Stores Generally.
2.—Office Buildings, Banks.
3.—Work Shops of Various Types.
4.—Factories, Mills.
5.—Hotel Dining-Rooms, Lobbies, Staircases.
6.—Churches.
7.—Theatres, Ballrooms.
8.—Ordinary Houses, Schoolrooms, Reading Rooms, Libraries.
9.—Draughting Rooms, Counting Rooms.
10.—Railroad Stations, Train Sheds.
11.—Decorative Illumination.
12.—Special Illumination.

Since the requirements of each of the above types of artificial illumination will vary, it will be necessary to discuss in another paper the principal requirements of the above classes separately, and, whenever possible, to point out some instances where efficient illumination has been obtained for the particular class of work described. At the same time, sonsiderable instruction will result by pointing out some errors that are common in the interior illuminations of the different classes. Of course, it does not follow that the exact order above referred to will be employed in these discussions.

A Long Electric Railway

A CONTRACT has recently been signed for the construction of an electric railway in Washington, which will be 146 miles long, the longest electric railway in the world. The organization is controlled by a number of Spokane capitalists, of whom J. P. Graves is the president. The system for electrifying the line is of the Westinghouse single-phase alternating-current type.

Power for operating the road will be obtained from the Washington Water Power Company, which has harnessed the waters of the Spokane River, and the electric current will be transmitted at a pressure of 4000 volts to the power station of the railroad company. From this station electric current will be transmitted along the line of the track at a pressure of 50,000 volts to fifteen transformer sub-stations located along the line. In these stations the current will be reduced for the operation of the motors on the cars.

A New German-Austrian Combination

A SCHEME is being promoted which will have the effect, on completion, of reducing from three to two the number of large firms engaged in electrical engineering in Austria-Hungary. The first group is the Austrian Siemens-Schuckert Works Company, which was formed a year or two ago, while the second relates to the projected establishment of a community of interests between the Austrian Union Electricity Company, which is closely associated with the Allgemeine Company, of Berlin, and the firm of Ganz Company, of Buda-Pest.

The scheme proposes the complete severance of the electrical engineering department of Ganz & Company, and its transformation into an independent company. The majority of the shares in the new concern will be held by Ganz & Company, while either all or a portion of the remainder of the shares will be taken over by those interested in the Union Company. On the other hand, the firm of Ganz & Company, or the Hungarian Credit Bank, will acquire a block of shares in the Union Company. In addition to these financial interchanges, the scheme provides for the division of markets between the Union Company and the new (Union-Ganz) company, and the mutual utilization of experience and new inventions.

Electric Motors in Italy

WRITING under recent date from Milan, Italy, United States Consul Dunning says that to supply power for the various branches of industry in Italy there are now in operation 63,599 motors, classed as follows:—Hydraulic, 49,699; steam, 8150; electric, 3621; gas, oil, and wind, 2129. Gas motors in Lombardy number 1847, with a total horse-power of 64,527. Commercial gas, distinct from illuminating gas, is sold here at a low rate, and is attracting a considerably growing number of manufacturers to its use. Even yet, however, the hydraulic motor has a long lead, there being 10,000 of them in Lombardy, with a total horse-power of 100,000. The opportunity for a steady-going and economical gas motor in Northern Italy seems good, though American makers must expect to compete with Italian mechanics, who are noteworthily clever and who are already producing a gas motor which is attracting much attention in the country.

The electric motor is also coming into more general use in Italy and is beginning to contest with the gas motor, a field previously occupied almost exclusively by the hydraulic motor. In Milan more than one firm is turning out electric motors for this very purpose, and American manufacturers will have to meet them on their own ground. In Lombardy, that is, the Milan district, there are already nearly 1300 electric motors, and the number is constantly growing. Electric power sold at a comparatively low rate, on account of the sharp competition from gas and water.

The Nernst Lamp in Textile Establishments

An interesting paper on the application of the Nernst lamp to textile establishments was read at the recent semi-annual meeting of the New England Cotton Manufacturers' Association, by A. T. Holbrook, of Boston. Mr. Holbrook described the early development and present construction of the lamp at considerable length, and then discussed the special fitness of the electric light in textile manufacture as illustrated in the use of the Nernst type.

In describing the design of the lamp the author stated that recent tests have shown the ballast to be able to stand, without injury, a constant overload of 5 per cent., and variable momentary loads as high as 25 per cent. As at present manufactured, the lamp is made in the following sizes:—

Type	Candle-Power	Amperes	Volts	Watts	Watts per Candle-Power
"Baby"	25	0.25	220	55	2.2
1 glower ...	60	0.4	220	88	1.46
2 glowers ..	125	0.8	220	176	1.40
3 glowers ..	200	1.2	220	264	1.32
4 glowers ...	300	1.6	220	352	1.17
6 glowers ...	500	2.4	220	528	1.06
"Baby"	25	0.4	110	44	1.76
1 glower ...	60	0.8	110	88	1.46

The best results are secured at present with 220 volts, but all 220-volt lamps may be operated on 110-volt circuits by the use of a small raising transformer or converter coil, placed directly above the lamp.

Referring to the use of gas in various industries, Mr. Holbrook emphasized the singular fact that many manufacturers, otherwise alive to a strenuous competition in trade and the vital necessity of having low operating costs, continue to use an illuminant generally conceded to be unsuitable for the purpose. Gas is not sanitary; the open-air flame as well as the Welsbach lamp consumes oxygen needed for the use of the worker; the heat is oppressive, and from it come particles of dirt which will quickly soil anything in the immediate neighbourhood. To its use can be traced many troubles which make a staff of employees inefficient, and a factory subjected to more or less direct losses.

The one recommendation of gas is that it is somewhat cheaper than electricity, but with the Nernst lamp even this advantage is lost, the actual cost of operation, candle-power for candle-power being essentially the same. The open flame or fish-tail burner consumes 5.47 cubic feet of gas per hour and delivers 13.4 candle-power; the Welsbach mantle consumes 3.75 cubic feet of gas per hour and delivers 40 candle-power; the ordinary incandescent lamp consumes 50 watts per hour and delivers 16 candle-power; and the 1-glower Nernst lamp consumes 88 watts per hour and delivers about 60 candle-power. The comparative cost of operation of the above with gas at an average price of $1 per thousand cubic feet, and electricity at a manufacturing cost of 4 cents per kilowatt-hour is.—

	Cost Per Lamp	Per Candle-Power-Hour
Fish-tail burner..........	$0.00547	$0.00040
Welsbach mantle	0.00375	0.00009
Incandescent lamp	0.002	0.00012
Nernst lamp	0.00352	0.00005

Electricity is flexible, sanitary, easily controlled; it does not leak, and in the matter of fire risk it is vastly superior, with proper inspection, to gas. The tendency is toward large lighting units in the attempt to approach daylight conditions. Individual low candle-power units do not distribute well, and the operative is frequently obliged to bring his lamp down to his work in order to produce certain results. This causes delays and breakage, which are sources of annoyance and expense.

The Nernst lamp is closely akin to the arc lamp in shape and general characteristics, but it avoids certain disagreeable features closely identified with the latter. The light is steady at all times and the colour value is so perfect that all colours appear under its light in their true shades. With it the most delicate shades can be matched. In dye-house work it is invaluable, and the fumes and gas have practically no effect upon its mechanical construction. All of the light is thrown downward, and looms, spinning frames, twisting machines, cone winders and others can be illuminated with great satisfaction.

Great difficulty has been experienced in securing a suitable light for the inspection room, and for that department alone the lamp should be used, even if nowhere else. Mr. Holbrook said that imperfections in fabrics are more readily noted than with any other artificial light, and more and better work can be produced if the lamps are used. In inspecting raw cotton it is possible to secure results with the Nernst lamp which would otherwise be obtained only in daylight.

The cost of keeping the Nernst lamp in repair is about the same as that of the arc lamp, but on account of the long life of the former, it needs less frequent attention. Enclosed arc lamp carbons have an average life of about 150 hours, and Nernst lamps, about 800 hours. Where series arcs are used, their advantage is more marked, as a whole bank of lamps must be shut down until the entire lot is trimmed. The 6-glower lamp will illuminate 400 square feet satisfactorily; the 4-glower, 300 square feet, and the 2-glower lamp, 200 square feet.

In case mills are not in a position to use Nernst lamps on account of their direct-current equipment, but would like to do so in their dye house, inspection room, and laboratory, Mr. Holbrook recommended the additional installation of alternating-current central station service. The Arnold Print Works, at North Adams, Mass., have been using the Nernst lamp in their dye house for about six months on this arrangement with great satisfaction.

The Saco and Pettee machine shops in Biddeford, Maine, are illuminated by 700 3-glower Nernst lamps, hung 15 feet from the floor in a proportion of one lamp for every 200 square feet of floor area, and their illumination is understood to be very satisfactory. The mill was considered unusually difficult to light on account of the numerous pulleys and cross belts. Although the work is of the closest nature, it is possible to perform it in all its details without the use of a single individual light.

Electric Power in Canadian Coal Mines

The Canadian coal mines owned by the Dominion Coal Company, are to be worked by electric power. H. F. Parshall, the English electrical engineer, recently completed a preliminary investigation of the company's mines, as a result of which it has been decided to install at some central spot a plant capable of supplying electric power to all the collieries. The work will be undertaken at once, and, as a preliminary instalment, three electrical machines of 650 H. P. each have been purchased. These the company expect to have in operation in the early spring.

From this central station power will be transmitted by wire to the various collieries, thus doing away with the maintenance of the individual boiler and engine plants at present operating the respective collieries. The maintenance of a boiler plant at the various pumping stations will be done away with, and these will all be operated by electricity.

The longest distance at present over which power will be transmitted will be a distance of about 8 miles.

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The Development of the Ontario Power Company

By P. N. NUNN

One of the features of the annual meeting last month at Toronto of the Canadian Society of Civil Engineers was a visit to Niagara Falls, and the inspection of the several hydro-electric developments at that place, prominent among them the works of the Ontario Power Company. An electrically cooked luncheon was served to the Society at the company's distributing station, and the various points of interest in this latest of Niagara plants were made available for examination. The only account of the plant thus far given was prepared by Mr. P. N. Nunn, of L. L. & P. N. Nunn, engineers of the Ontario Power Company, in the form of a paper read at the last annual convention of the American Institute of Electrical Engineers, and this, through the kind co-operation of the author, and of the Institute, we are enabled to reprint in the following pages. Since Mr. Nunn's paper was written, three of the generators of 10,000 H. P. each have been completed and put in regular service.—The Editor.

THE development of electrical power at Niagara Falls has long attracted widespread attention and interest. Since the first installation upon the American side, descriptions and discussions of its works and methods have been granted a conspicuous place in technical records and scientific press. It is not so well known, however, that four other developments, each larger than the pioneer, are now drawing or preparing to draw power from Niagara River. These differ so widely and so apparently as to type and character, and express such differences of conception and method that it seems fitting at this time, when the largest is about to enter the active field, to present before the Institute, and through the channels of its proceedings to the technical world, a brief description of a few features peculiar to this plant and a statement of the considerations which have led to so fundamental a departure from the type of construction hitherto characteristic of Niagara Falls.

Standing upon the upper steel-arch bridge and facing the Canadian falls, one may observe at the foot of the cliff forming the right-hand wall of the gorge, a long but unobtrusive building, its farther end obscured by spray from the great cataract. It is of modest, though massive design, and its colours almost blend with those of the overhanging cliff. This is the power house or generating station of the Ontario Power Co. To the right, high above and behind the power house, upon the bluff overlooking both gorge and cataract, may be seen another great structure, less massive, but more ornate, which, on account of its commanding position, is by far the most prominent landmark of the Canadian side. This is the distributing station of the same company, from which the power generated below is controlled, measured and transmitted. Away to the left, around the bend of the river and hidden by the trees of Goat Island, are the walls, abutments and buildings of the intake and head-gates through which the water from Niagara River is diverted for use below. In the park between these extremes, seen just beyond Horse Shoe Falls, stands the power house of the

GENERATING AND DISTRIBUTING STATIONS DURING CONSTRUCTION

BIRD'S EYE VIEW OF NIAGARA FALLS, SHOWING POWER DEVELOPMENTS ON THE CANADIAN SIDE

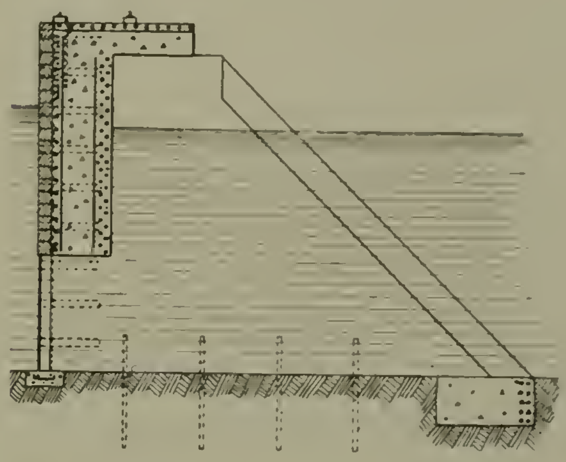
Canadian Niagara Power Co., while to the left another power plant, that of the Electrical Development Co., is rapidly building.

From the head-gates of the Ontario company three great steel and concrete tunnels or conduits beneath the surface of the park, will convey nearly 12,000 cubic feet of water per second to the top of the cliff above the power house. Thence it will pass through twenty-two steel penstocks in shafts and tunnels down and out through the cliff to an equal number of horizontal turbines in the power house below. From the generators the electrical cables turn back through tunnels to the twenty-two banks of switches, transformers and instruments of the distributing station above, and to the transmission lines beyond, completing an equipment for more than 200,000 H. P.

The intake-works for the entire 200,000 H. P. are now finished. One of the three main conduits is completed, while for the second and third, portals and head-works have been installed and a portion of the excavation made. Six of the twenty-two penstocks are already in place within their shafts and tunnels, and two others are building, while the power house is nearly prepared for the concomitant apparatus. The distributing station is completed for the switchboard of the entire twenty-two units, for the transformers of eight, and for other apparatus of fourteen. As to equipment, the coming month will witness one complete unit being operated, a second being tested, a third being installed, and a fourth being completed at the factories, with other units to follow as equipment of such size can be manufactured and installed.

The purposes and methods followed in the development of the pioneer plant and the environment and natural conditions at Niagara Falls have become so well known that interest in this younger development necessarily centers in its salient features or in those most likely to represent advance in engineering. The more important of these are the arrangement of intake-works, the design of main conduit and spillway, the horizontal shaft units, the symmetry of arrangement, the centralization of control, and the protective isolation of apparatus.

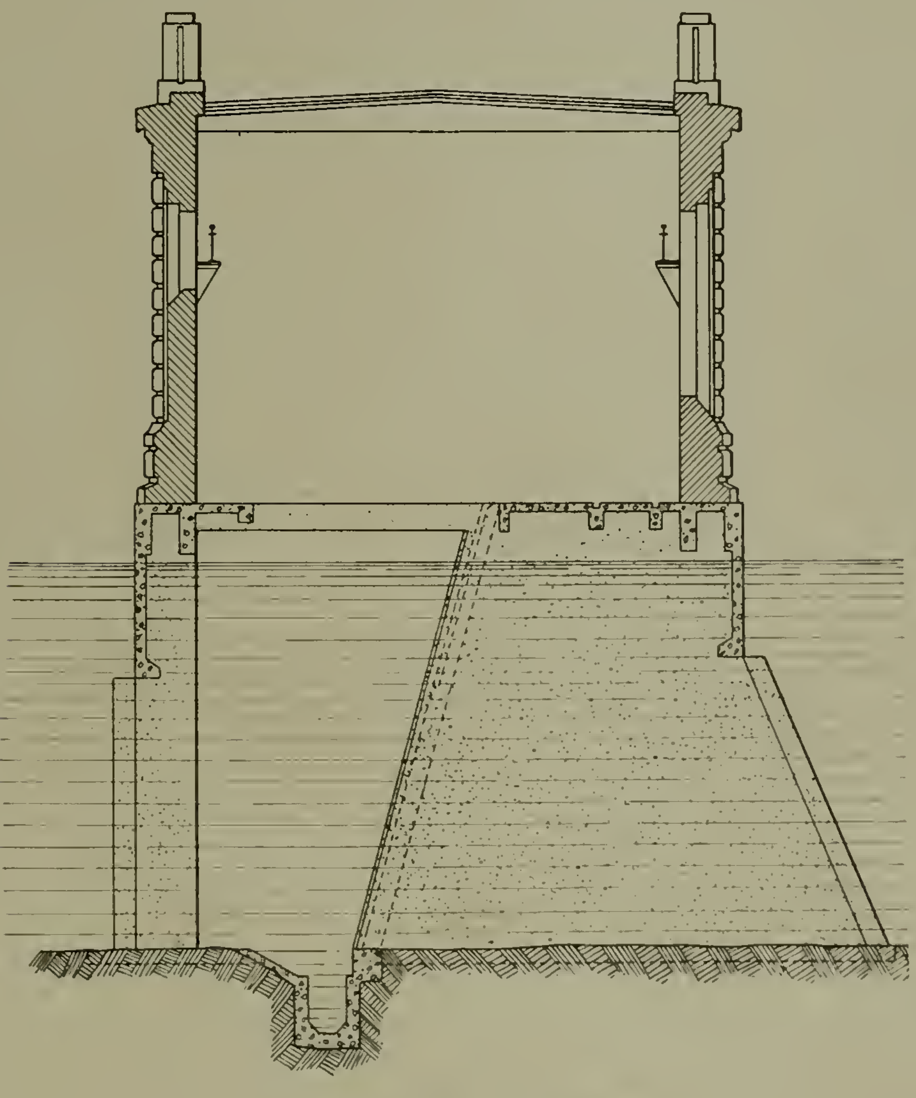
The intake-works have been located and designed with especial reference to the ice difficulties which have been the limiting factor in the success of Niagara power. Cake ice in enormous quantities floats down for weeks at a time from the Great Lakes, and mush ice is formed in the turbulent rapids primarily by the freezing of spray and foam and secondarily by the disintegration of cake ice. To avoid the latter the intake is located in the smooth but swift water just above the rapids; to exclude the former the following features have been introduced. A long and tapering forebay protected at its entrance by the main intake terminates at its narrow, down-stream end in a deep spillway. Upon the river side it is enclosed by a submerged wall, while the other side adjacent to the spillway is occupied by the main screen structure leading to the inner bay and to the portals and head-gates of the three conduits.



SECTION THROUGH INTAKE

The intake, nearly 600 feet long, stretches across the inlet or bay at Dufferin Island almost parallel with the current in the river. Throughout its length a concrete curtain wall extends down 9 feet into the water, here 15 feet deep, so that the gate openings beneath admit only deep water, and this at right angles to the swift exterior surface flow which, sweeping the full length of the curtain, carries the floating ice to the rapids beyond. At the main screen this operation is repeated. This structure, 320 feet long in 20 feet of water, lies across the entrance to the inner bay and parallel with the direction of flow in the outer bay. Again a curtain, formed by the front wall of the enclosing superstructure, admits to the screens only deep water, here also at right angles, while it excludes ice with the surface currents maintained through the forebay by a voluminous spill of surplus water.

At the gate structure, where the water is 30 feet in depth, the tapering portals leading to the electrically operated Stoney head-gates are protected with wide-mesh screens which are also enclosed and safeguarded by a curtain carried by the front wall of the gate house. The bay in front of the curtain communicates with the river by an ample ice-run. Substantial concrete buildings shelter both head-gates and main screens. In each case an open canal between curtain and screen spills into a gravity ice-run emptying into the river. Both buildings are supplied with steam for



SECTION THROUGH SCREEN HOUSE

MAP OF NIAGARA FALLS, SHOWING LOCATION OF POWER DEVELOPMENTS

PLAN OF THE ONTARIO POWER COMPANY'S INTAKE WORKS

heating and thawing from an underground boiler plant situated in the common abutment.

Thus the water before entering the conduits must pass in succession three automatically selective steps, each excluding surface water and its floating ice, and two screens, each behind ice-runs in heated buildings containing live steam for emergencies. Serious trouble is not believed possible while these provisions are maintained with reasonable care.

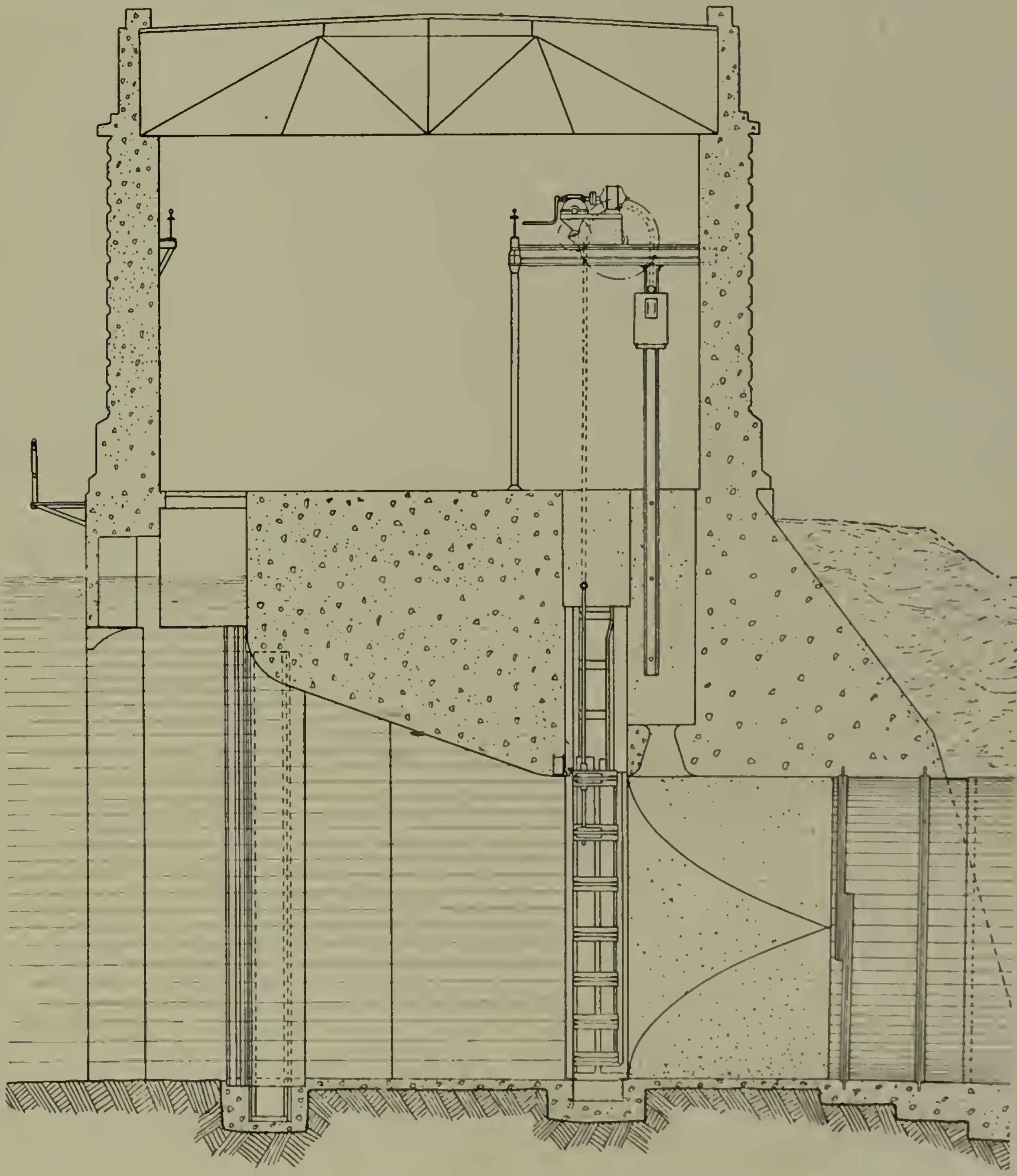
Screen frames are removable by an electric crane for cleaning and changing. On account of its location in the public park, the top of the long, narrow screen house, approached at either end by broad steps and landings, is finished as a promenade. From this point of vantage one may have a superb view of the upper rapids. The islands and channels made in the course of this work give great opportunity to make this portion of the park most picturesque.

The height of the water in Niagara River, and therefore the volume here available, is dependent upon the surface elevation of Lake Erie, the erosion of the river bed, and such temporary causes as ice gorges, storms, etc. From calculations based upon comparative observations extending over a number of years and upon government reports of Lake Erie levels for nearly fifty years, the elevations of the intake have been so selected that at extreme low water and most adverse conditions a full supply of water should be secured.

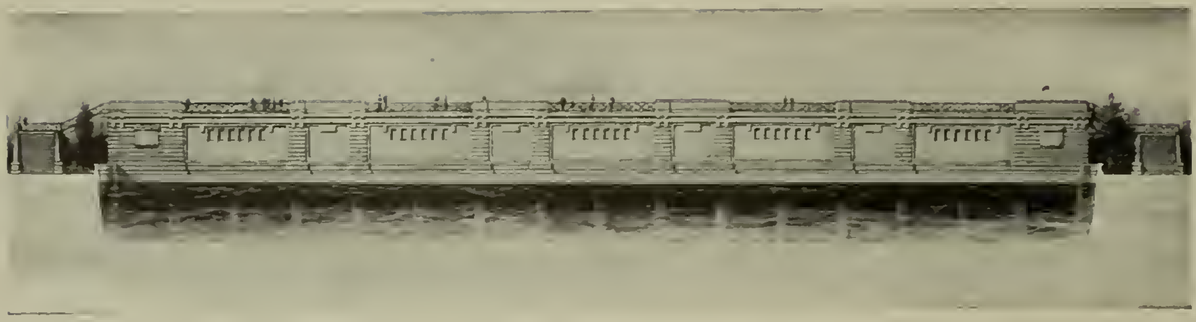
The main conduits are of 0.5 inch riveted and reinforced steel imbedded in concrete, 18 and 20 feet in diameter, 6500 feet long, and are buried within the rock and soil of the public park. Through them the water flows at a velocity of approximately 15 feet per second. Just beneath the top of the cliff behind the power house, within a long underground chamber, the arched roof of which supports the conduit above, 9-foot diameter branches pass from the under side of the conduit through gate valves and become the penstocks, each supplying water at 10 feet per second to a single turbine. Each penstock has two expansion joints, a massive thrust anchorage in the power house foundations, and an automatic relief valve and a stone catch discharging into the river. The 9-foot valves are electrically operated under distant control from the power house below, and are so constructed that all working parts may be removed for attention while the penstocks are in service.

The spillway at the end of the conduit, to prevent water hammer in case of sudden loss of load, is little more than the enlarged and elevated end of the main conduit equipped with an enclosed weir and underground discharge. Its peculiar features are its adjustable weir and a steep initial pitch in the taper from helical discharge tunnel which, after the weir, follows a uniform grade and symmetrical curve while circling about to reach the river, thus pre-

EXTERIOR VIEW OF THE GATE HOUSE

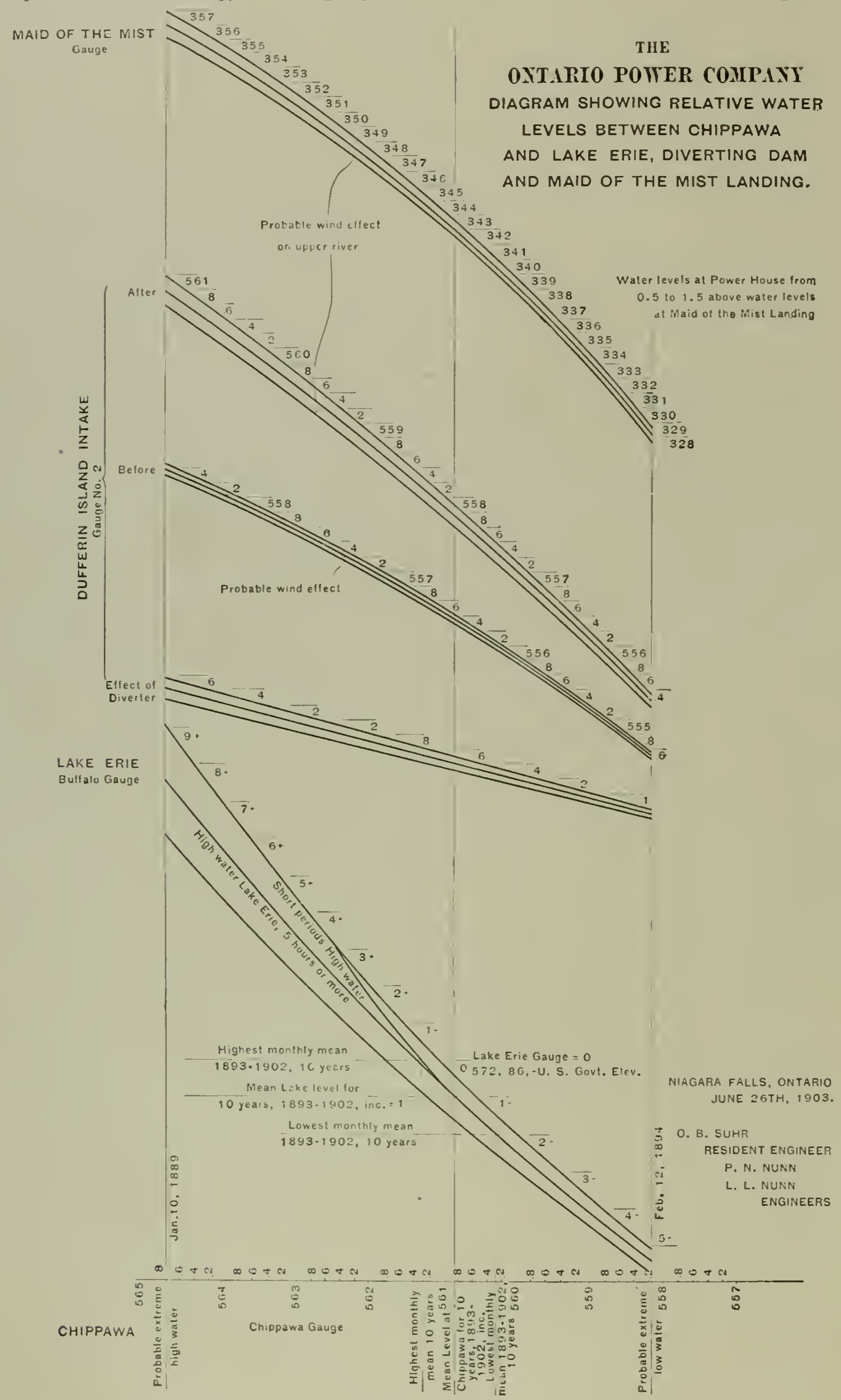


SECTION THROUGH THE GATE HOUSE



EXTERIOR VIEW OF SCREEN HOUSE AND PROMENADE

serving a smooth, unbroken water column of highest velocity and least expenditure of energy. The purpose here is to prevent erosion, restricted flow and excessive air suction, the latter on account of the danger of formation of ice from spray under forced circulation of air.



The generators are of conventional horizontal-shaft type, three-phase, 25-cycle, and deliver 12,000 volts at 187.5 revolutions per minute. The turbines are of Francis or inward-flow type, double, central discharge or balanced twin turbines designed to deliver 12,000 H. P. under 175-foot head. Their shafts are of 24-inch maximum diameter, and each carries two 78-inch cast-steel runners of "normal" reaction. Housings are of reinforced steel plate, 16 feet in diameter, spiral in elevation and rectangular in plan. Gates are of the wicket or paddle type, and the rotating guides forming them are carried by shafts which project through stuffing boxes to an external controlling mechanism, thus freeing the castings from the objectionable interior gate rigging and leaving their approaches to the guides symmetrical and open. While the velocities in housings and draft tubes are high, corresponding losses are avoided by nicely modulated changes of both velocity and direction and by symmetrical and liberal curves free from abrupt angles or obstructing projections.

Of the 175-foot head, 20 feet is in the 10-foot diameter draft tubes, because the floor of the power house has been elevated 26 feet above mean water level to provide for the excessive variations to which the water in the gorge is subject. While bearings are self-oiling, all are equipped with water-cooling system, and for still greater insurance a piping system for the changing of oil has been so connected that in emergency it is instantly available for forced lubrication. Believing that disorders of bearings and journals, like those of people, are usually the culmination of gradually increasing ailment, each bearing is supplied with an automatic record-making thermometer providing the superintendent with a daily record, not only of the temperature of the bearing, but also of the temperament of the attendant as well.

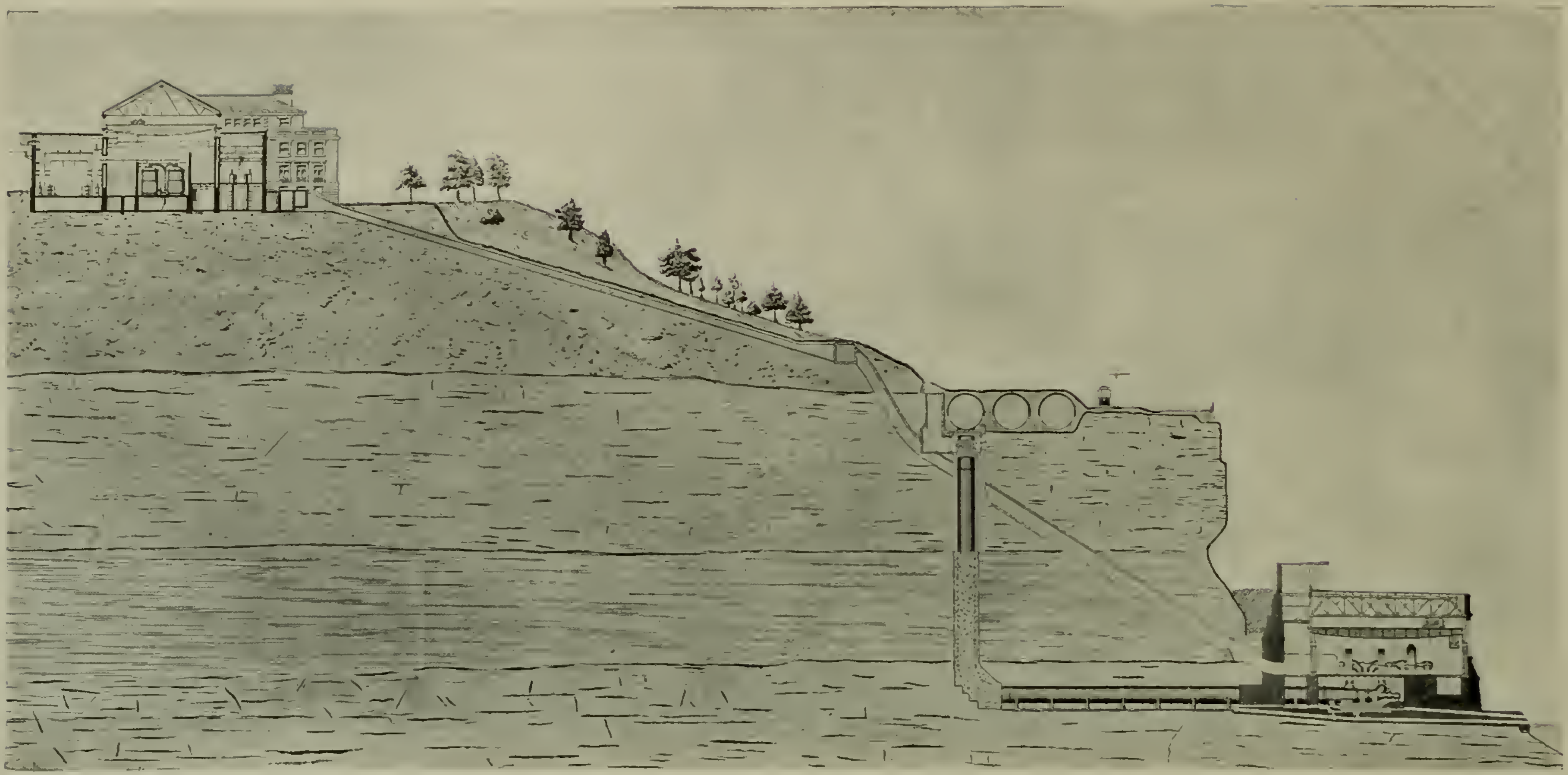
Although entirely feasible to use the vertical-shaft turbine and although restricted space at the power house requires greatest floor economy, nevertheless horizontal units are employed on account of their freedom from step-bearings, their higher efficiency, and their greater accessibility. While step-bearings in certain places are entirely successful, as long since proved by screw propellers and more recently by vertical team turbines, yet at best they entail much auxiliary apparatus requiring especial care and frequent adjustment. With high-head turbines they have an un-

certain record to be shunned wherever continuity of service is essential.

To reduce load upon the step-bearing, the vertical unit is usually of highest permissible speed. While efficiency at the generator is favoured by this high speed, the effect upon the turbine is diametrically opposite and usually many times greater. This is because highest efficiency and durability seem to require "normal" reaction—a radial relative direction of bucket entry—and narrowly limited relative dimensions of runner. At such reaction, peripheral velocity of runner (the components of which—diameter and rotation—are inversely proportional) is fixed by head. At such relative dimensions power is proportional to square of diameter, hence, inversely proportional to square of rotation. Increase of rotation, therefore, means disproportionately great decrease of power or abandonment of ideal reaction and relative dimensions. When carried to the extremes usual with vertical units, it results in inefficiently high reaction and reduced area of discharge, unfavourably abrupt changes of direction in buckets, and a wastefully distorted and overworked wheel. To

MAIN CONDUIT DURING CONSTRUCTION

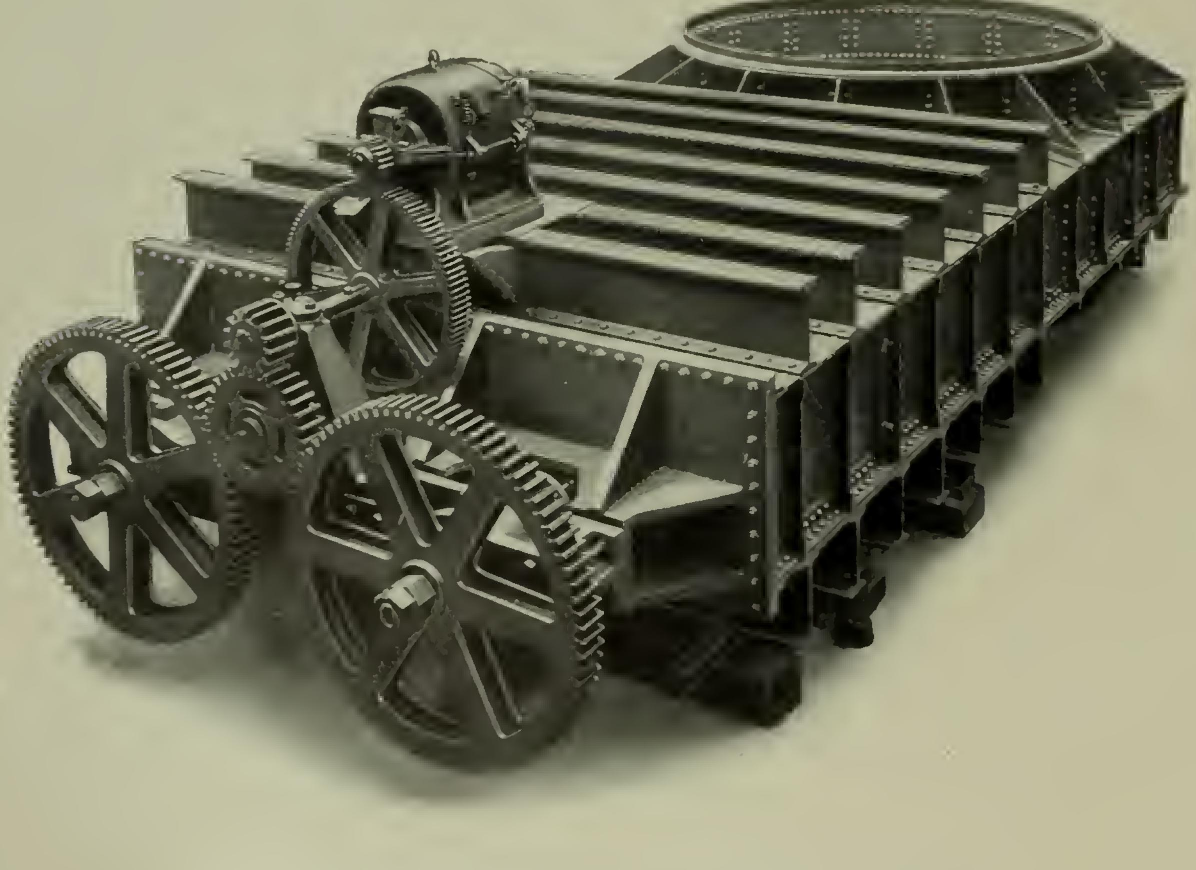
BIRD'S EYE VIEW, SHOWING GENERATING AND DISTRIBUTING STATIONS COMPLETE FOR 200,000 HORSE POWER



SECTION THROUGH GENERATING AND DISTRIBUTING STATIONS

such an extent is this distortion carried to meet especial conditions that it is rare to find a high-head turbine possessing nearly the efficiency or durability possible if correctly proportioned. In the present case the speed selected permits almost exact "normal" reaction and ideal proportions without sacrifice at the generator.

Gratifying accessibility has been obtained by compact arrangement of generators and turbines with ample clearances and good light, upon the main floor of the station and in full sight not only of the immediate attendant, but also of the chief operator from his post upon the gallery above. As explained, the entire gate rigging is external, therefore accessible for lubrication, adjustment or repair. Excepting runners and gates, every moving part is in plain sight, and, by the ready removal of a single ring, even the guides themselves are exposed for cleaning or replacing. This arrangement, in strong contrast with that of the vertical type with its several floors, intervening stairs and dark corners, will, it is believed, appeal to every power house operator.



ELECTRICALLY OPERATED VALVE FOR NINE-FOOT PENSTOCK

In the general arrangement of the works, symmetry and centralization of control are predominant characteristics. The generating and distributing stations are parallel and nearly 600 feet apart with 260 feet difference in elevation. On account of limited space the generating station is but 76 feet wide, though when completed it will be nearly 1000 feet long. Down the center of this building, side by side in a single row, stand the generating units with turbines next their source of supply. The space between them and the rear wall is occupied by a gallery upon which stands the row of oil-pressure governors, each almost over the end bearing of its turbine.

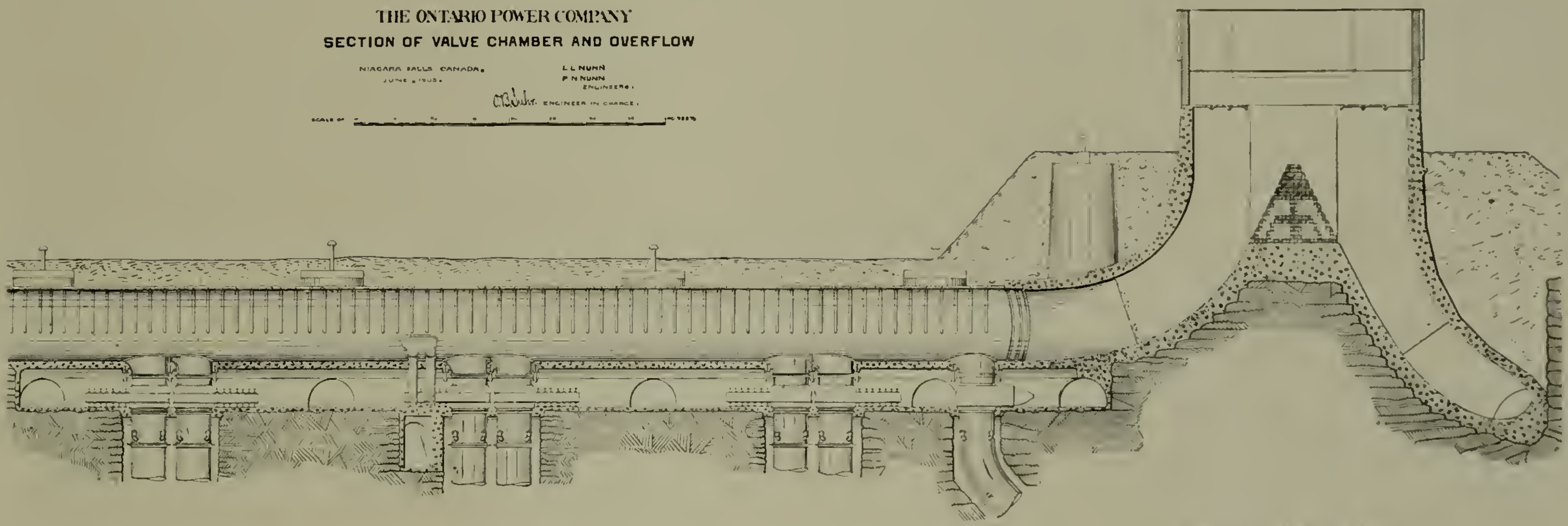
The distributing station, wider and shorter than the power house, is divided into three longitudinal bays or five main sections. The narrow front bay contains the switches, bus-bars, etc., at generator pressure; the wider rear bay contains those at transmission pressure. Between these, stretches the main middle bay, divided transversely by a three-floor switchboard section into two long transformer rooms. The projecting central section provides space for the operating offices. Along the center of these two rooms the transformers stand in groups of three, corresponding in position and capacity to their respective generators. Thus similar apparatus is arranged in rows parallel one with another and with the generating units.

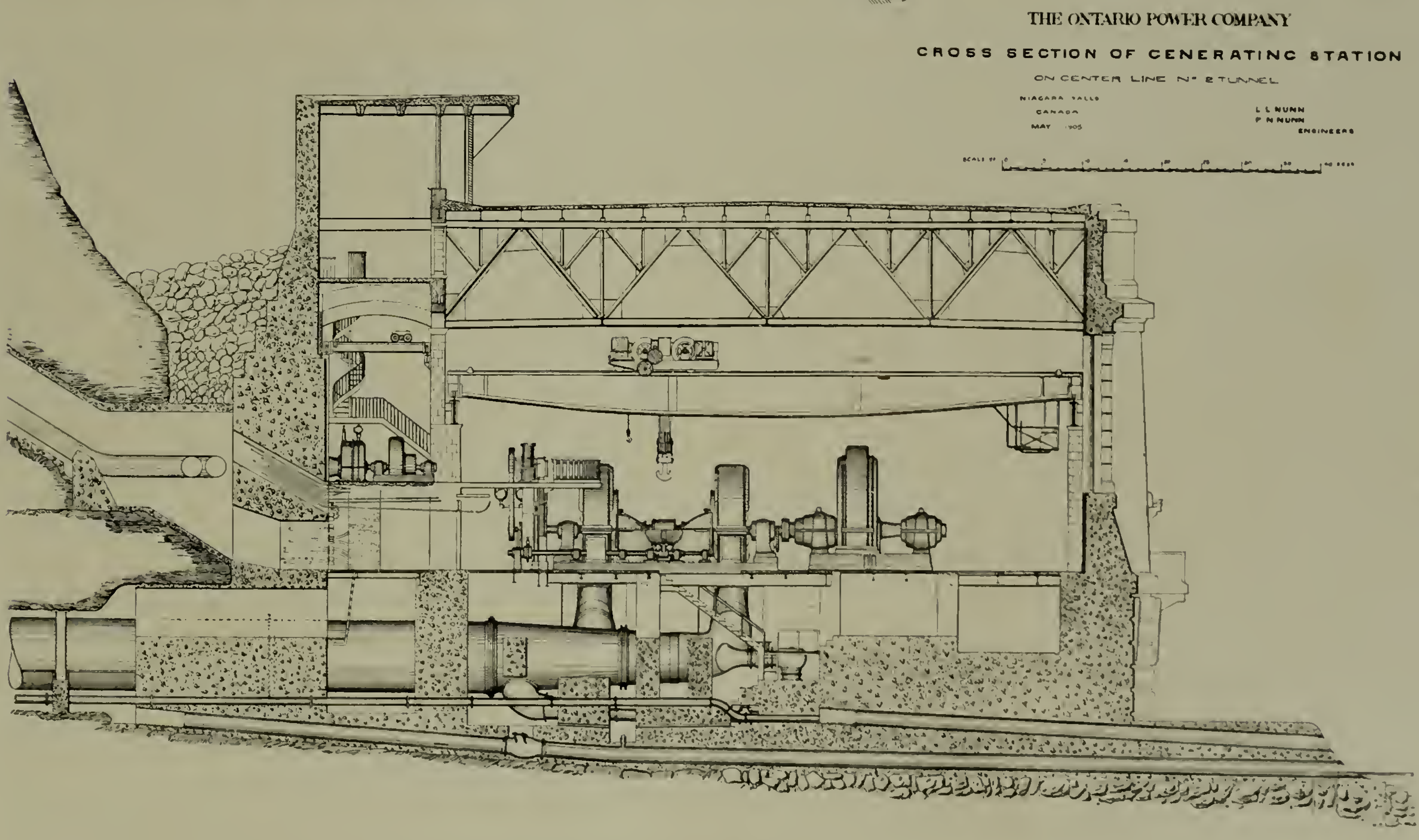
At the generating station three inclined cable tunnels, one already built, carrying clay ducts, begin at the rear wall beneath the gallery and extend up through the cliff, and, as standard subway, on to the distributing station. The main cables, except as diverted by these tunnels, follow the shortest and most direct routes from generators to transformers. They do not converge for the accommodation of switchboard at one or more centers where congestion prevents separation or adequate insulation, and in many installations causes the most disastrous accidents. On the contrary they are laid quite regardless of switchboard, the switches and instrument transformers of which are then placed as required by the cables.

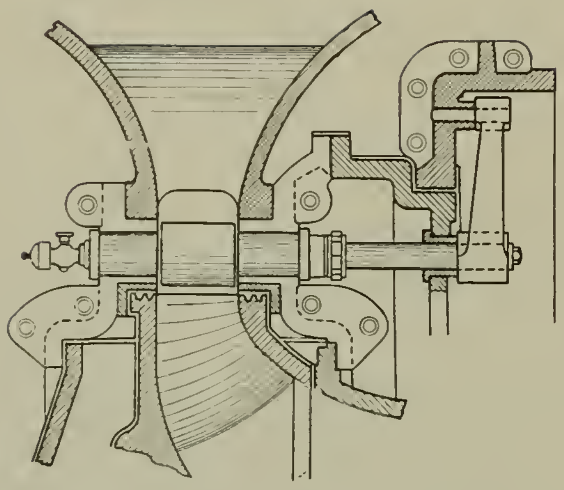
Unit values, corresponding to the generators in capacity and position, are maintained throughout. Thus each generating unit has its individual cables, switches and switchboard, section bus-bars, transformers, interrupters, and high-pressure switches complete to the transmission, enabling independent operation as an isolated power plant, or, through the selector switches and duplicate sectional bus-bars, the operation of all units in any combination of groups as readily and perfectly as their operation in parallel. To this end a unit length of distributing station of similar relative position is devoted to the circuit and apparatus corresponding to each generator.

From the above it may be seen that the arrangement is in parallel courses; that like apparatus is arranged in rows or courses parallel with the long axis of the generating and distributing stations; that the main circuits and the unlike apparatus performing the successive functions of these circuits form twenty courses transverse to the same, and that the courses of the two directions form, as it were, a rectangular or checker-board figure covering an area nearly 1000 feet square. The arrangement of these courses in logical sequences provides the short and direct route for the main cables previously mentioned. Such symmetry of arrangement, while difficult to attain in a crowded plant or at points of congestion, is of marked value in emergency, especially in a plant of many units, and becomes vital when the units are of such dimensions that the accidental crippling of one costs the output of many smaller plants.

Where the cable tunnels commence,







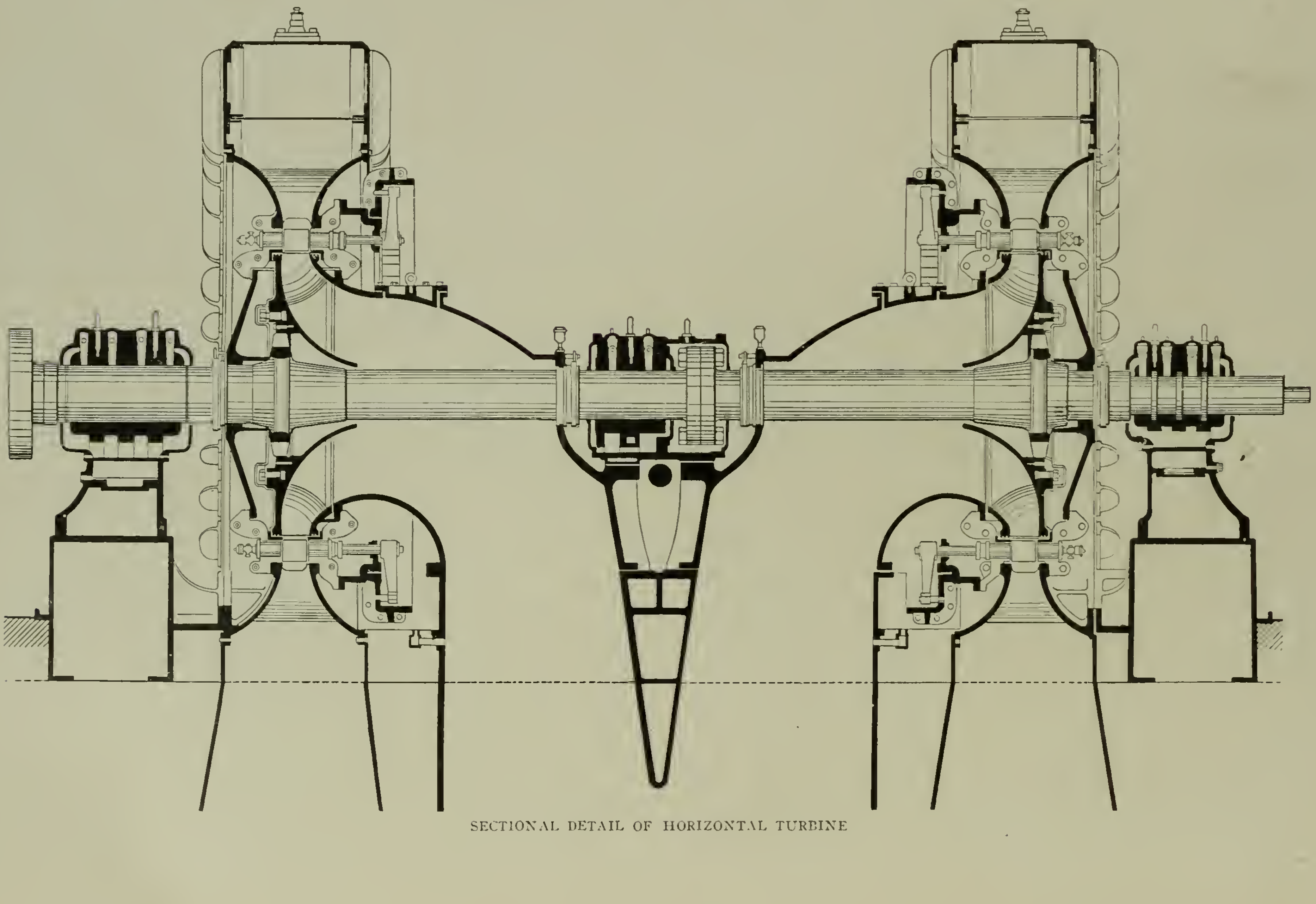
OPERATING MECHANISM OF TURBINE GATE

the power house and gallery are widened toward the cliff. Immediately above the tunnel entrance are the main generator switches, and on one side the duplicate turbine-driven exciters and their governors, and on the other the motor-actuated main field rheostats. In front of the switches are a few panels of switchboard carrying exciter rheostats and switches, controls for actuating penstock valves, and the necessary circuits and apparatus for a limited local distribution. Relief valves and small drainage pumps are the only operating machinery beneath the main floor, while upon it, in addition to the generating units, there are only duplicate electrically driven pumps supplying the storage tank and transformer cooling coils at the distributing station. For air circulation and ventilation and to avoid dampness from spray as well as to insure cool generators in hot weather, a cold air supply to each generator is provided from a sub-floor chamber communicating with external shafts and heated air escapes through large roof ventilators.

At the distributing station the low-pressure bay contains upon the main floor the 12,000-volt automatic oil circuit breakers in double column, and in the chamber beneath, only the sectional duplicate bus-bars and their immediate connections. In the transformer rooms the transformers stand in pits 6 feet below main floor level, and parallel with them adjacent to the high-pressure bay are corresponding pits for static interrupters or other protective apparatus. Beneath both and between their foundations are accommodated the several systems of piping for water, oil and drainage and the main cable-ways to the transformers above. Each transformer is fitted with a record-making thermometer giving the continuous history of internal economy.

The switchboard section occupying the center of the distributing station has four floors, of which the basement serves as a center for the piping systems and gives room for conduits and cableways for wiring. On the main and the mezzanine or gallery floors, marble slabs carry record-making and integrating instruments, terminal boards with fuses for the control cables, and other adjuncts of the switchboard above. Upon the upper floor is the switchboard and control chamber, and here instrument stands and control pedestals supplant both the conventional marble slabs and the later bench-board. Each of the twenty-two instrument stands, which are arranged approximately in a semicircle about a central point, corresponds to a definite unit, carries nine indicating instruments and faces its twelve-point control pedestal. Doors upon the four sides lead to balconies in the four other divisions of the building of which this room is the center, those at the sides to balconies extending the full length of the transformer rooms.

Centralization of responsibility and authority, at defined points within the immediate personal care of a minimum number of chief operators, is, next to simplicity of arrangement, the prime requisite of efficiency of organization and of economy of operation. It is frequently possible so to arrange small plants of a few units as to centralize a single operator, but with a plant of this scope



SECTIONAL DETAIL OF HORIZONTAL TURBINE

that result is manifestly impossible. Two alternatives are then open: the division of the plant into several parts, each about its sub-center constituting a complete plant in itself and the whole dependent upon successful co-operation for unity of result; or classification and centralization of responsibility according to kind. In this case the latter has been adopted, and notwithstanding that the number of units and aggregate of power involved have opposed high merit in this respect, a promising result has been obtained.

The concentration within a single room of all instruments and control—the brain of electrical operation—provides the operator in a quiet and secluded place both full information, and perfect control of every electrical circuit and situation of the system and enables him to stop, start, regulate or synchronize each unit, to throw its output through its transformers to its transmission as if from a complete isolated plant, or to throw it upon either bus-bar while supplying its transformers from the same or the other bus-bar. The location of this room high up at the geometrical center of the distributing station places the operator at a point of vantage surrounded by four classes of apparatus. Thus located he may with few steps survey his entire field, look down upon switches, bus-bars and arresters of the high-tension, see at a glance every low-pressure switch, or watch trouble in either transformer room.

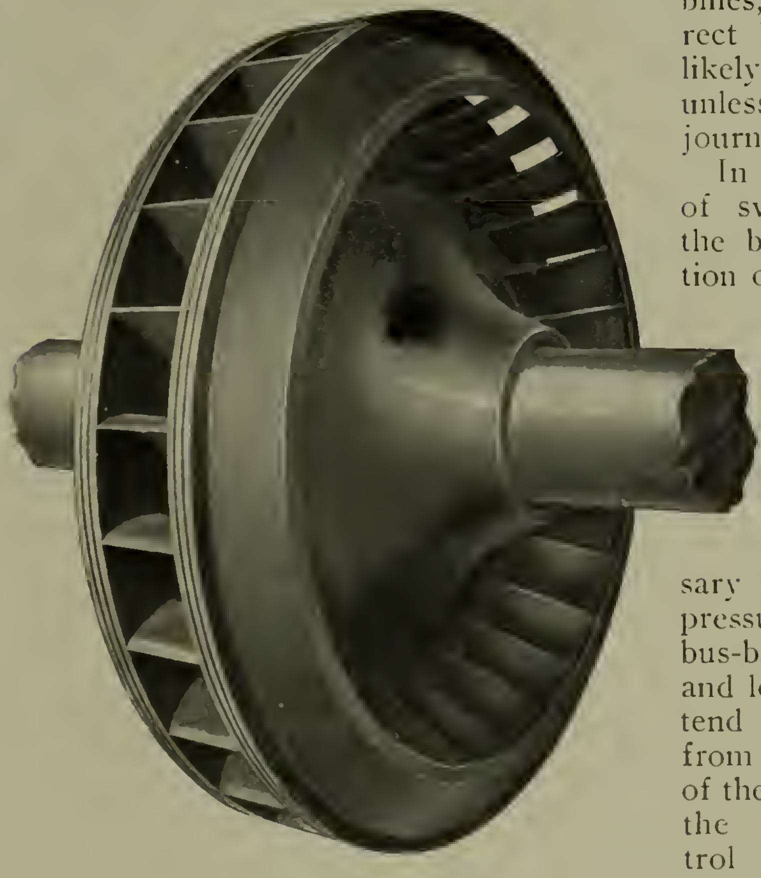
At the generating station, the corresponding vantage point is the gallery, where on one side the operator has the motor-driven rheostats and a few paces distant the commutators and governors of the exciters, and on the other side in plain sight the row of main governors with their adjuncts; while from the little switchboard before him he has electrical control of penstock gates, and, when necessary, manual control of turbine speeds, exciter pressure and field charge. Moreover from this position he can see all generators and turbines, and, by signal at least, can direct his assistants; little, in fact, is likely to call him to the main floor, unless it be an occasional refractory journal or collector brush.

EIGHTEEN-FOOT DIAMETER CONDUIT, SHOWING CONCRETE ENVELOPE

In accomplishing the centralization of switchboard simultaneously with the broad and symmetrical distribution of main circuits and switches already described, distant electrical measurement and control have necessarily been employed to an unusual extent. Pressure and current transformers, essential to the many instruments and relays beyond those necessary at generating station and high-pressure room, are mounted in the bus-bar chamber. The innumerable and long conductors, necessary to extend over the intervening distance from those to the many instruments of the switchboard and to convey back the power from relays and control buttons to automatic switches, have been gathered into substantial cables and laid in metal conduit.

The basement of the central bay along its low-pressure side forms a wiring chamber supporting a railway track upon the main floor above. Through this wiring chamber transverse to the general direction of the main cables and opening at its center into the control section, these cables and those for both continuous and alternating current local service are carried into the basement beneath the control section, and rising through the recording floors, end at terminal boards below their respective instruments and relays. Carried thus far, distant control has been still further applied by the use of motor-driven rheostats for both generators and exciters, electrically operated circuit breakers for field circuits, and speed controllers for governors, whereby, as previously mentioned, turbines may be started, stopped or regulated from the control chamber as well as from the gallery at the generating station.

The isolation of electrical apparatus and conductors by incombustible walls or barriers against spread of oil or arcs, for protection from fire and from each other, is of importance proportional to the power and investment involved. Neglect of this precaution has caused many of the most disastrous electrical accidents and has recently taught several bitter lessons. Some rather extreme measures here taken for its more complete application may be of in-



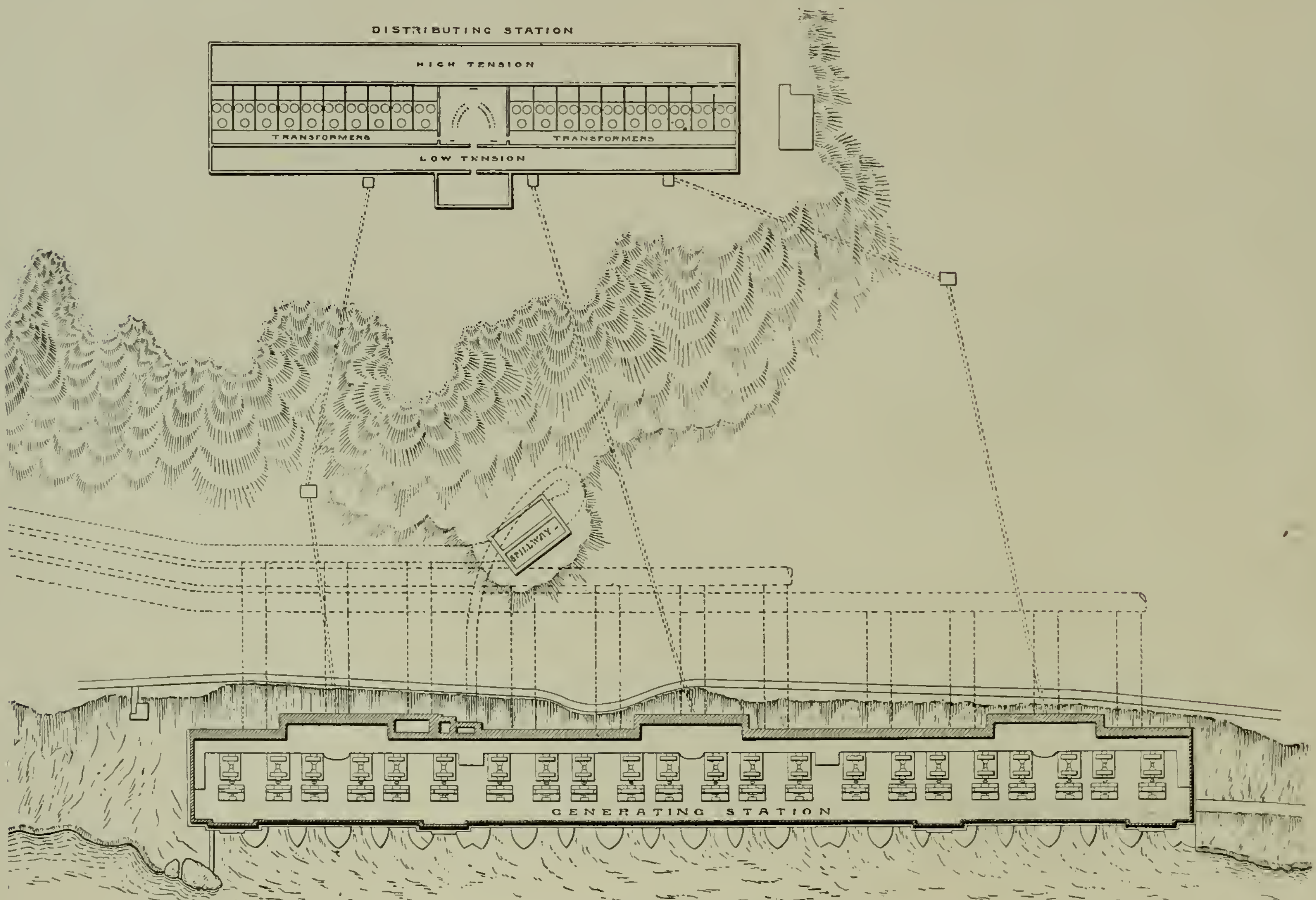
A TURBINE RUNNER

SWIVEL GATE EXPOSED BY REMOVAL OF COVER RING

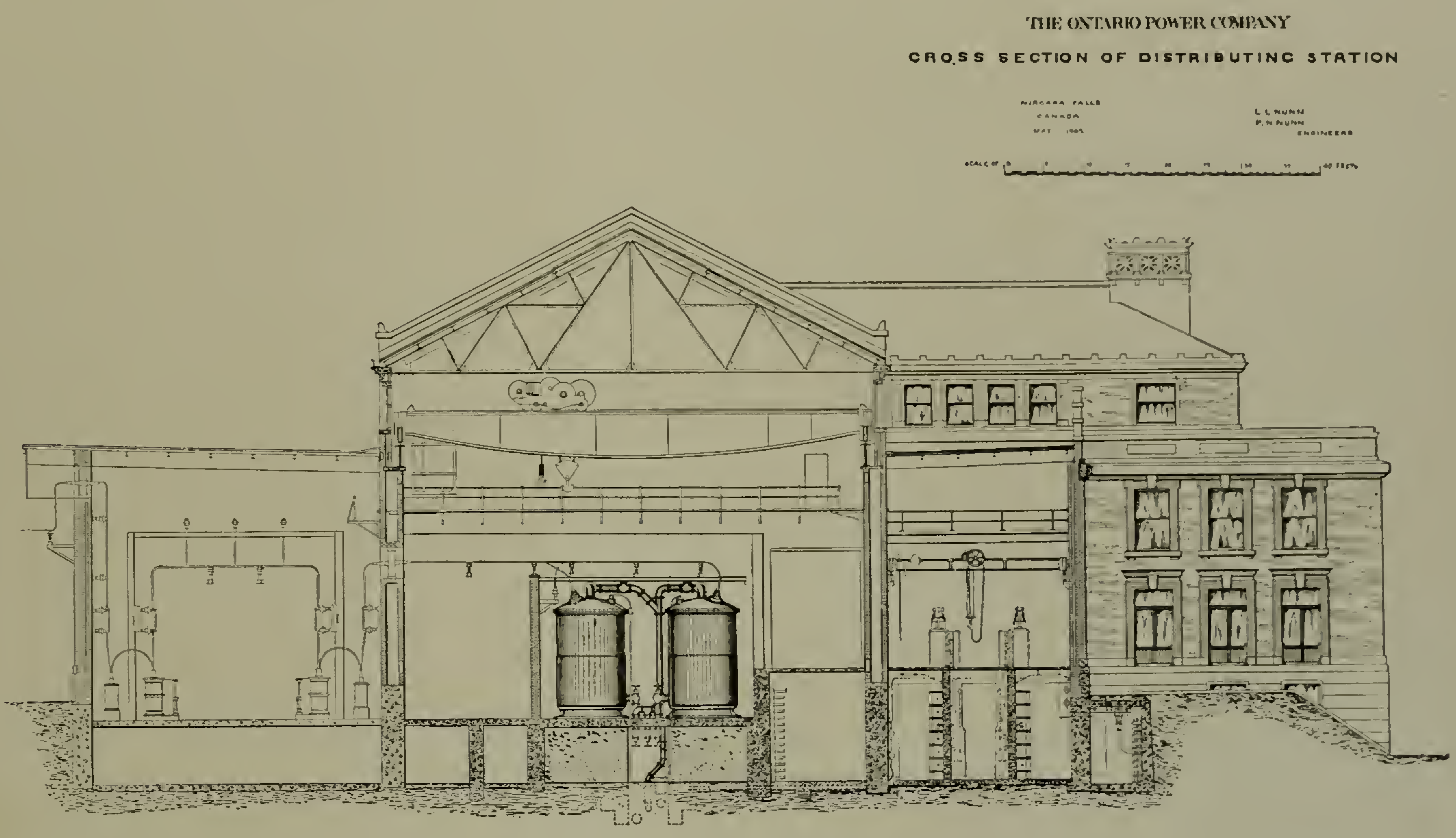
terest. The five sections or rooms, heretofore mentioned, forming the distributing station, are of concrete and steel fireproof construction, separated by full-height masonry walls with intervening air spaces. No windows and but few doorways (these latter protected by fireproof doors usually closed) penetrate these walls.

The transformer pits, already mentioned, each containing a bank of three transformers, are isolated and extended to a height of twenty-three feet by masonry fire-walls. Each individual transformer is in a boiler-iron casing designed to withstand 150 pounds per square inch explosive pressure. Each case communicates through an 8-inch pipe from its top with a special drain for free vent in case of accident, as proposed before the Institute some time ago; but here the supply is cold oil instead of water as then proposed. With these precautions it is believed that the transformers have been surrounded with an environment unprecedented as to safety.

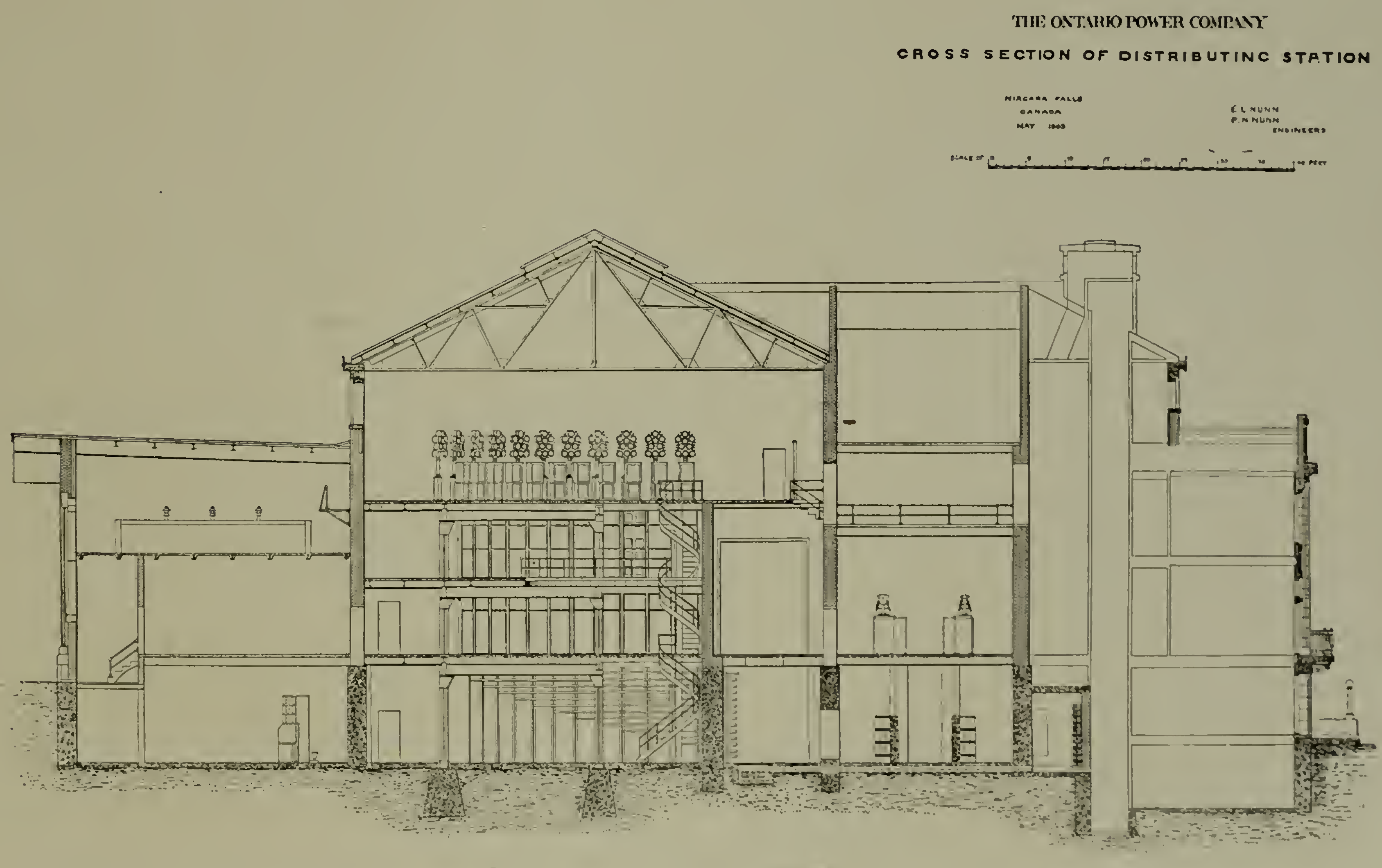
The power from each generator is conducted to its switch through three single-conductor braided cables carried by line insulators and isolated by shelf barriers in a subway beneath the floor. From the switches the three conductors pass to a bell chamber where between individual barriers they are united into two parallel three-conductor, lead-covered and armored cables before entering the tile ducts of the cable tunnel. Around



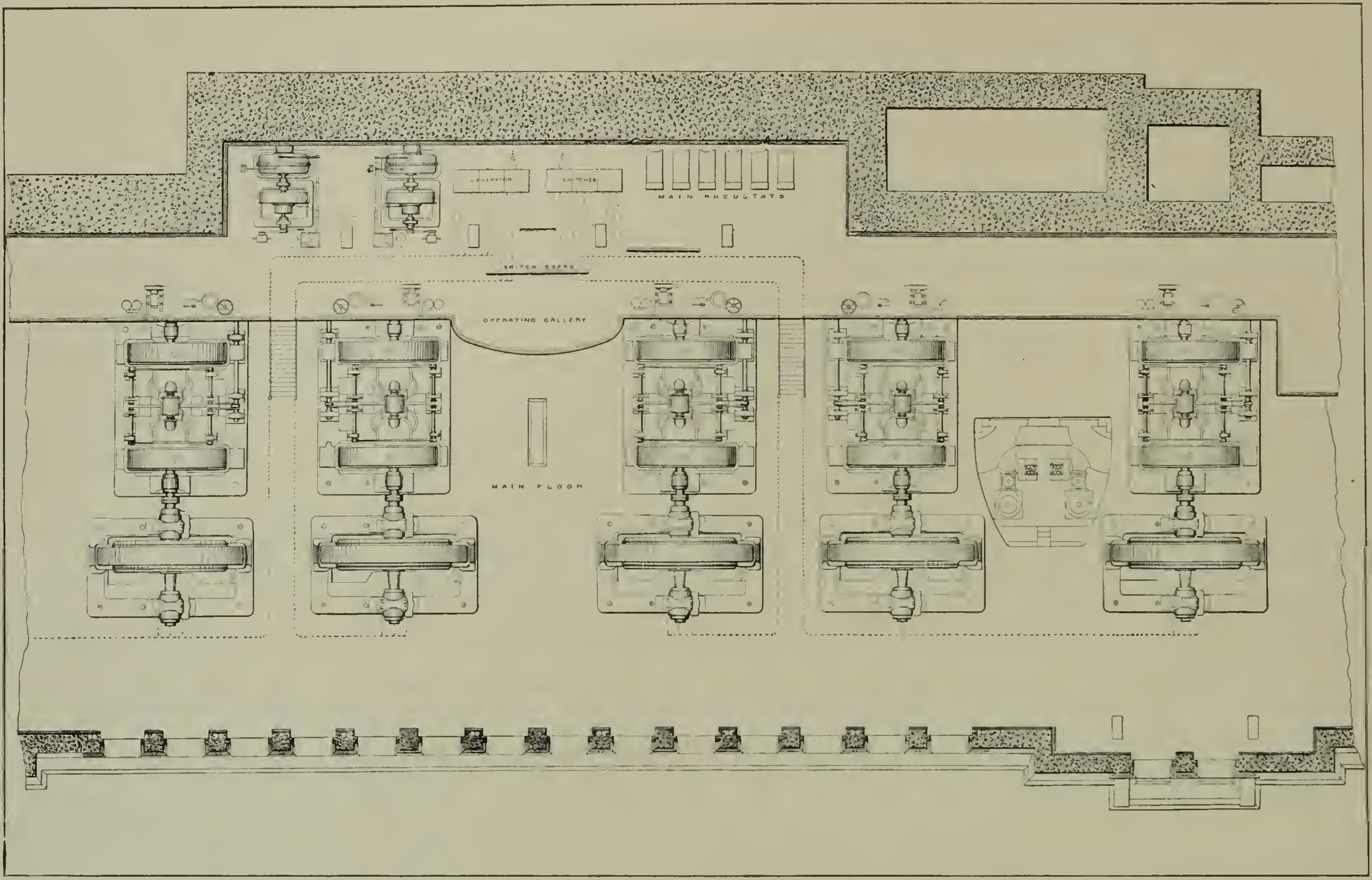
PLAN OF ELECTRICAL WORKS



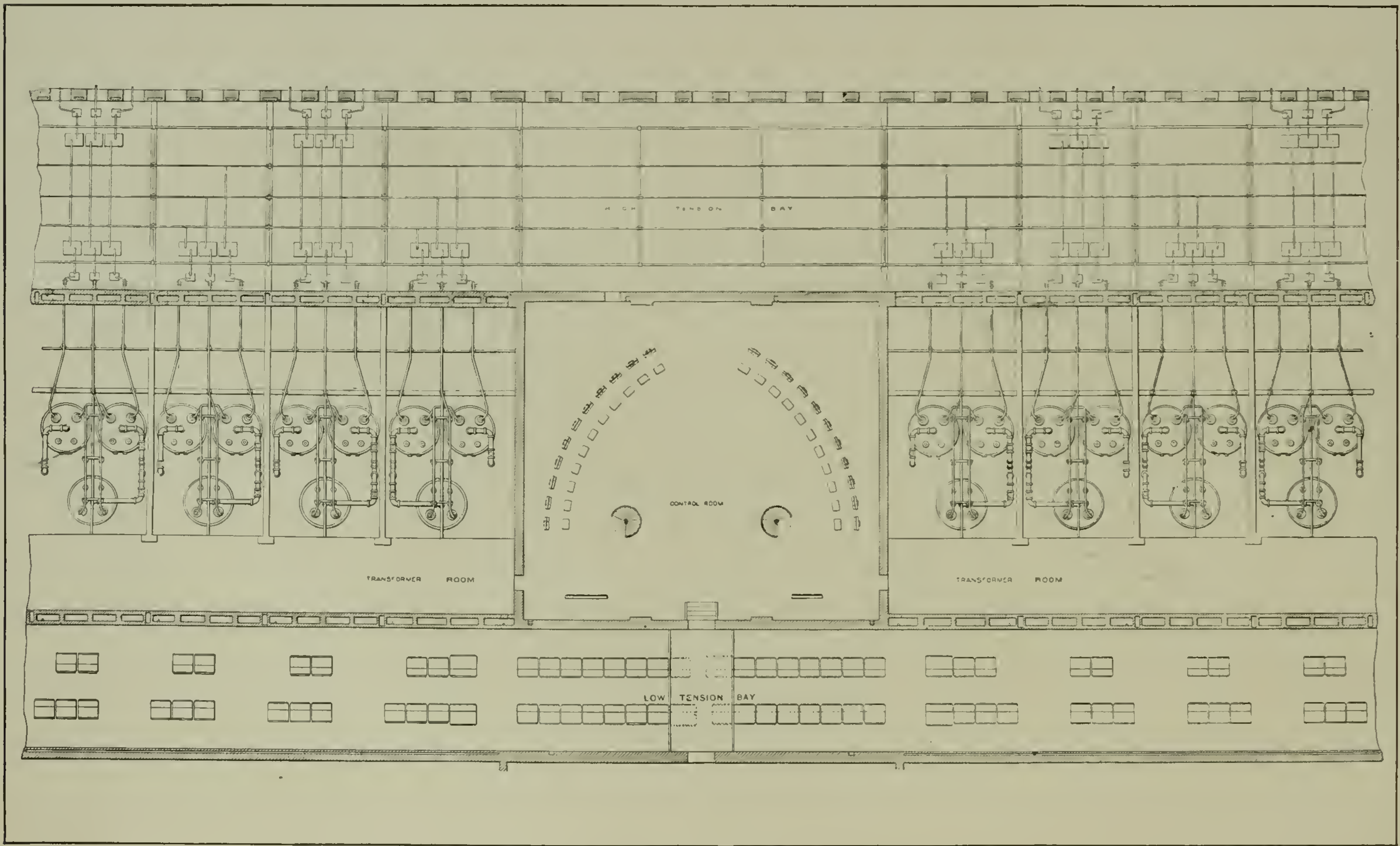
SECTION THROUGH TRANSFORMER ROOM



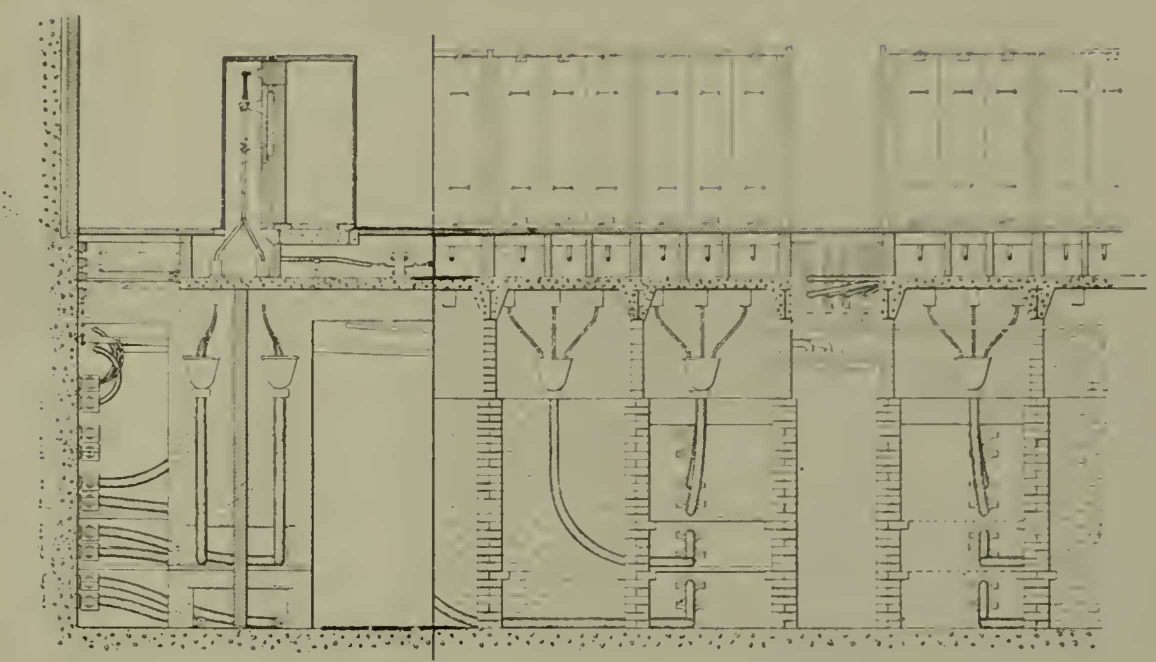
SECTION THROUGH CONTROL CHAMBER



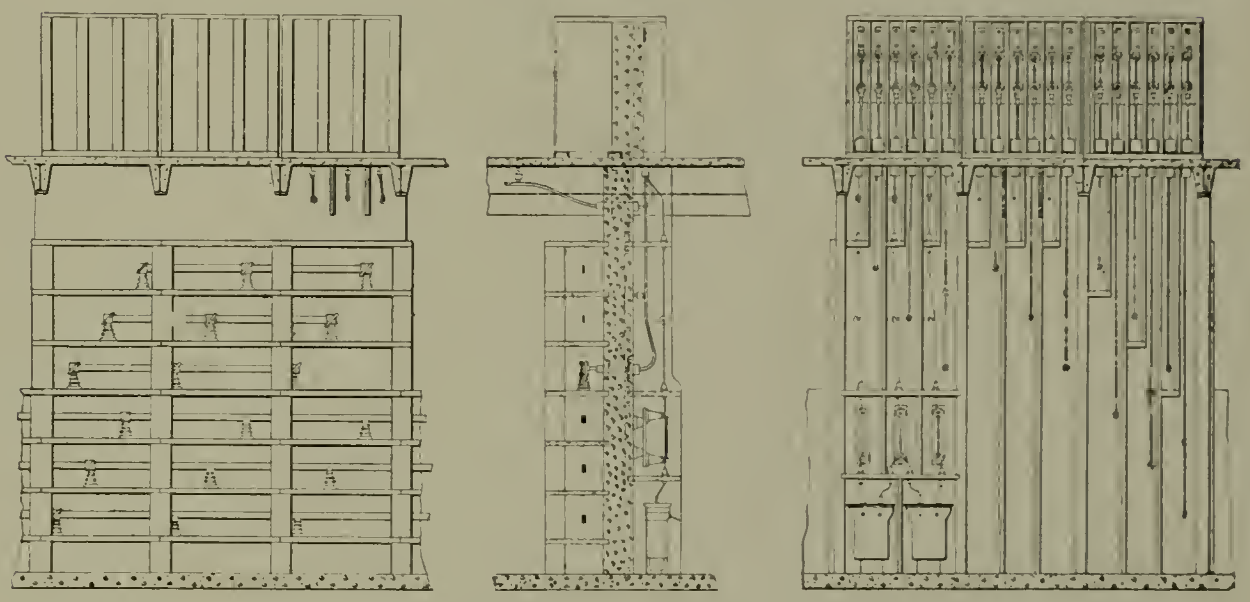
PLAN OF GENERATING STATION, UNITS 2 TO 6



PLAN OF CENTRAL PORTION OF DISTRIBUTING STATION



CABLE BELL COMPARTMENTS AND BARRIERS



FRONT, REAR AND SECTION OF BUS-BAR STRUCTURE AND SWITCHES

the few bends at manholes each cable remains always within its compartment, between horizontal or vertical barriers as required. At each point where a circuit enters the distributing station, a manhole maintaining the same segregation and communicating with the bus-bar chamber is provided for the change from three-conductor to single-conductor cable. After entering the building, the cables pass between vertical barriers as before mentioned, beneath and through the floor to the switches above.

Bus-bar structures are composed entirely of concrete with mortised reinforced concrete shelf barriers between bus-bars. Connecting leads pass through the wall forming the center of the structure, and thence in compartments formed by vertical barriers of the same material, directly up to the switches above. Instrument transformers are also installed within similar individual compartments and these whole structures, like those of the switches, are closed by fireproof doors. Control cables are laid in metal conduit throughout their courses, except in the wiring chamber beneath the track, where they are arranged upon metal shelf pans filled with dry sand, into which connecting conduits dip.

Of the features here presented, it is believed that the type of intake, the symmetry of arrangement, centralization of control, and almost perfect isolation of apparatus represent, to some degree at least, distinct advances in power-plant design, and while few works of such dimensions may be built for many years, if ever, the purposes and methods thus briefly presented may, until superseded by the next advance, be of service as suggestions to other designing engineers of similar works. The unusual, even enormous volumes, both of water and of power, involved not only in the individual units, but also in the aggregate, have presented new problems heretofore unprovided for in standard sizes of apparatus, thus necessitating the development of larger capacities and the creation of new types. Hence the work of designing and building has been burdened with incessant test, redesign and adaptation unknown in more conventional engineering. Therefore, it is believed that upon no similar work in this country, since that of the Niagara Falls Power Co. years ago in the infancy of electrical power, has developed such a burden of investigation, invention and original design.

It has been suggested that any account of this work would be incomplete without mention of those mainly responsible for it. Justice to all is here impossible, but a few may be named. Mr. O. B. Suhr has from the beginning been in charge of the engineer corps, and to him is largely due the harmony of design. V. G. Converse, C. H. Mitchell and J. B. Bailey are chiefs of the electrical, mechanical and field departments respectively, and J. R. Harsch of the clerical work of the engineers.

Smelting by Electricity in Chili

IT is reported that smelting by electricity will in a few years play an important part in Chili, as there is a rich supply of water-power from the Cordilleras, particularly in the neighbourhood of the iron and other ore deposits. By the construction of dams the water could be made even more serviceable. In the neighbourhood of the iron ore deposits there are several valuable rivers, e. g., in Central Chili, the Maipo, the Mapocho, and the Aconcagua; in the province of Copuimbo the Illapei, the Choapa, the Limari, and the Coquimbo; and in Atacama the Huasco. Already a company, the Sociedad de Altos Hornos (smelting furnace) Electricos, has been founded in Chili by an Italian, Jose Pedro Alessandri, which will deal with copper as well as iron. The company is seeking to acquire several water properties, especially those of the rivers Teno and Tinquiririca.

In order to determine the possibilities and advantages possessed by electricity for culinary purposes, says "The Engineer," of London, a dinner was recently given to a party of sixty-five persons by the organizers of the electrical exhibition at Olympia. A seven-course banquet was cooked in the same room in which it was eaten, and it was announced that the amount of current consumed was 56 British thermal units, costing 1d. per unit, or 4s. 8d. altogether for heat. The cooking was considered thoroughly satisfactory, and would seem to show that with suitable apparatus of a reasonable price and current on day load terms, there is room for a large increase in this cleanly form of heat production.

A Hydro-Electric Power Installation in British India

AN important power scheme to be shortly undertaken by the government of British India is that on the Jhelum River in Kashmir, in Northwest India. This plant is to be installed near Rampur, about 50 miles below Srinager, where a 6-mile conduit will give a head of water at the plant of about 400 feet. The present plans call for an installation of about 20,000 horsepower.

It is planned to use the power for operating the 180-mile Kashmir section of the Jhelum Valley Railway, and a single-phase system will undoubtedly be installed. Electric power will also be used in operating dredgers for deepening the Jhelum River in the Kashmir Valley. Another important use of the power will be for operating the large silk factory at Srinager and also for supplying with current the electrical water heaters in the silk mill. The power will also be utilized for other industrial purposes and for lighting in a number of towns lying to the west of Kashmir.

Major A. J. de Lotbiniere, R. E., deputy chief engineer of Mysore, who is in charge of the project, was instructed last May, by the Jammu and Kashmir State Council, acting for the Maharajah of Jammu and Kashmir, to proceed to Europe and America and secure bids for equipment from the leading hydraulic and electrical manufacturers.

As a result of careful investigation, Major de Lotbiniere recommended to his government that the contracts for the entire hydraulic and electrical equipment be placed with firms in the United States. The contract for the hydraulic plant complete from the forebay to the tailrace, was awarded to the Abner Doble Company, of San Francisco, including the intake, valves, pressure pipes, pressure-pipe thrust blocks, interior piping, water wheels and nozzles, hydraulic governors, and all details necessary for the hydraulic equipment. The apparatus and materials are to be delivered at the port of Karachi, India.

The gravity conduit line for the power plant will be approximately 34,000 feet long, and for the upper 8500 feet will consist of an excavated ditch lined with masonry. The remaining part will consist of a rectangular flume, or a wooden stave pipe such as has been installed so successfully in connection with plants of this character on the Pacific Coast. The flume will have a capacity of over 500 cubic feet per second.

The forebay at the end of the gravity line and at the head of the pressure pipes will be constructed of masonry and will be provided with special headgates. The pressure lines will consist of riveted steel pipes designed with a factor of safety of five, each supplying one of the hydro-electric units. For each pipe line a standpipe and two special vacuum valves will be provided in order to protect the pipe against injury in case the water should be drawn out suddenly.

At the lower end of each pressure line the last length of pipe will terminate in a flange, which will be bolted to a massive cast-iron thrust block resting on a heavy cast-iron sole plate or base. The last-named will be mounted on a substantial masonry foundation and held in position by anchor bolts. This fitting will be designed to take the entire hydraulic thrust of the pipe. Each pressure line will consist of a riveted steel pipe varying in diameter from 30 to 36 inches and a 54 to 36-inch taper pipe, 10 feet long, at the upper end. The pipes will be 790 feet in length and will deliver the water under an effective head of 400 feet. The interior piping of the power house will consist of welded pipe with welded flanges.

Twelve main units and three exciter units have been planned for the equipment of the power house. Each main unit will consist of a Doble tangential water wheel with automatic oil-pressure governor delivering 1765 brake horse-power to the shaft, under an effective head of 400 feet. Each wheel will be direct connected to a 1000-KW. alternator, the speed of the unit being 500 revolutions per minute. The exciter units will each consist of a Doble tangential water wheel delivering 285 brake horse power to the shaft under an effective head of 400 feet. The speed of the exciters will also be 500 revolutions per minute.

The hydro-electric units will be of the Doble standard two-bearing type, the wheel runner being fastened on the end of the shaft. The exciter water-wheel runners will be mounted on the extended ends of the exciter generator shafts.

The water wheels will be equipped with ellipsoidal buckets, needle regulating nozzles and centrifugal water guards. The regulation of the main units will be effected by means of hydraulic governors operating jet deflectors. For the exciter units hand regulation will be provided by means of the needle nozzles.

The power house will be of solid masonry construction and will have a wide veranda as a protection from the tropical sun. A double steel roof will be provided and two travelling cranes will be installed for handling the machinery. The transformers will be installed in a bay of the main building or in a separate structure.

The conditions under which the plant will be installed are decidedly out of the ordinary as compared with similar work in the United States. The specifications for the electrical and hydraulic equipment stipulated that no single piece of machinery should weigh more than four tons when packed, for the reason that there are 200 miles of road transportation, including a lift over a range of mountains 8000 feet high. Transportation in that section of the country is limited to bullock cart, and no single piece of machinery heavier than 4 tons can be transported, a total of 5 tons, including the trollie (cart), being the maximum weight that can be hauled over the mountains.

Portland cement costs $7.50 per barrel delivered at the site, making its use prohibitive for heavy concrete work. However, there is plenty of natural rock in the vicinity, so masonry construction will be used for the walls of the power house and for the foundations of machines, intake, forebay, and elsewhere.

The Chicago Street Railway Situation

AN ordinance was recently passed by the Chicago City Council permitting the city to purchase, build, and maintain street railways, the action being subject to a popular referendum vote at the election in April. The ordinance provides that the city may issue interest-bearing "street-railway certificates," not to exceed the sum of $75,000,000. The proceeds from the sale of these are to be used for the purpose of acquiring street railways by purchase, construction, condemnation, or otherwise.

A sinking fund will provide for the retirement of the certificates, this fund to be invested at compound interest. The properties acquired will be mortgaged to secure the payment of the certificates. All money received from the operation of the lines will be used for paying interest on the certificates, for operating and maintenance costs, and for adding to the sinking fund. If, however, there is a surplus after the sinking fund has been provided for, it can be spent on extension, which, however, shall not in any one year exceed 5 per cent. of the total mileage of the city's roads.

Minor Applications of Electricity to Railroading

By J. HANSON BOYDEN, Assistant Examiner U. S. Patent Office, Division of Railroads

INTRODUCTION

THE term, "minor applications," is here intended to include the applications of electricity for all purposes other than that of traction, which applications seem destined to become essential in the equipment of every progressive railroad. These may be classified thus:—

Rolling Stock	Permanent Way
1. Train lighting.	1. Switches—
2. Headlights.	1. Car-controlled.
3. Car signals.	2. Tower-controlled
4. Brakes.	2. Signals—
	1. Automatic.
	2. Tower-controlled

The foundations of practical electricity in this country may be said to have been laid by the introduction of the telegraph in the early forties. Since then electrical science has developed with a rapidity unparalleled in the history of the world, until it stands, to-day, one of the greatest engineering branches, intimately woven into our civilization. As each year added new discoveries, as the wonderful adaptability of electricity became more apparent to inventors and investigators, and as its laws became better understood, its applications increased. Not only was this increase noticeable in its original capacity as a conveyor of intelligence, or in its later roles as an illuminator and common carrier, but with a steady and irresistible movement it has crept into the shop, the factory, the hospital, the mine, the printing office, the navy, and even the kitchen, till at last there is scarcely an art in the whole range of human knowledge that does not know its touch.

Especially noticeable are the applications of electricity to railroading. It is a rather striking coincidence that railroading had its beginning in this country at very nearly the same time that Morse was exploiting his telegraph. For the last half century these two great branches of industry have grown up side by side, separately developed, and yet inseparably linked together, so that to-day the one can scarcely be studied without the other.

TRAIN LIGHTING

The earliest efforts in train lighting were made in England and France, about the middle of the last century, with primary batteries as power generators. These batteries, of course, proved too expensive and were abandoned. The next attempt to light trains by electricity was marked by the substitution of storage batteries for the primary cells. This was tried in England as early as 1881, and it will be remembered this was the year that Fauré took out his first patent on accumulators. Although the storage battery system was a big step in advance, and was much more practical, it had not yet been sufficiently developed and did not prove a commercial success at that time, but it was afterward adopted by many companies on the Continent, and was said to be cheaper than gas.

In Germany, in 1886, we find inventors busy on another scheme,—the axle-driven dynamo. This machine was provided with a centrifugal regulator to maintain a practically constant speed, as the speed of the train varied. A storage battery was provided to take up the load when the car was standing still. This, however, was not considered practical. About this time, in Germany also, two storage batteries were employed on each train in connection with an axle-driven dynamo, the one battery being used for lighting, while the other was charging. An automatic cut-out was employed to disconnect the dynamo from the battery, when, by reason of slow speed, the voltage fell too low.

In England, an attempt was made to operate lights by means of a separate engine and dynamo on the locomotive, supplied with steam from the main boiler. This system, however, owing to the inefficiency of the small engine, was soon abandoned as too expensive.

Coming now to 1890, we find still another train-lighting scheme being exploited. Each train was equipped with two axle-driven dynamos, mounted on the same shaft, the one for lighting, the other for regulation. The lighting machine was provided with two differential field windings, the one energized by a small battery, the other connected to the brushes of the regulating machine. If the train ran too fast, the dynamo magnetomotive force opposed that of the battery, and hence the voltage of the lighting machine was reduced, and vice versa. These machines were installed on the London & Brighton Railroad.

Quite recently (1905) it was announced that the state railroads of Prussia are to use De Laval steam turbines connected to dynamos for train lighting. The turbine and generator are built together in a compact unit, and are mounted on the locomotive boiler. The turbine is said to develop 20 H. P., and to run at 20,000 revolutions per minute. The dynamo gives 70 to 90 volts. Each car is provided with a battery of thirty-two storage cells. There will be used 48-volt lamps, the remaining voltage being absorbed by an iron wire resistance on the same principle as in a Nernst lamp, so that the voltage at the lamp remains constant in spite of the variations of battery, due to charge and discharge. Generally, the battery and lamps will be run in parallel, a red lamp being arranged to light up when the voltage of the battery becomes equal to that of the dynamo, and charging should cease.

In this country we find, even as late as 1900, comparatively few trains lighted by electricity. The advantages, such as less danger from fire in case of accident, etc., are, however, being more and more recognized. Since the introduction of better and more efficient electrical machinery, it is admitted that electric train lighting is cheaper than gas, besides possessing many other advantages. It has, however, been demonstrated that the method of lighting by storage batteries charged at each end of the route, is, owing to the low efficiency of batteries thus charged, the most expensive electric method. This method is, nevertheless, employed by some prominent roads, notably the Chesapeake & Ohio, with seeming success.

The dynamo for car lighting is, or may be, as already indicated, driven in the three following ways:—

1. By a separate engine, supplied with steam from boiler of locomotive.

2. By a gas engine, mounted on any convenient part of the rolling stock.

3. By axle driving, the dynamos being usually mounted on the truck and provided with suitable gearing.

The first method is expensive, and has the disadvantage that the lights are inoperative when the train is disconnected from the locomotive. The second method has its advantages, and may be suitable in some cases. The third method, however, is the best and most widely used to-day, especially when employed in connection with a storage battery to carry the load when the car is at rest. With this arrangement, a comparatively small capacity is required, and therefore the battery is correspondingly less heavy.

In 1901, the system of train lighting from an axle-driven dynamo, had assumed considerable importance, and we find it spoken of even at this date as having "long passed the experimental stage." Its chief promoters at that time were the Consolidated Axle Light Company. This company, later known as the Consolidated Railway Electric Lighting & Equipment Company, of New York, continues to do a large business.

Each car is equipped with its individual generator and storage battery, the outfit weighing about 2000 pounds. Differential compound machines may be used for regulation purposes, as already described, but shunt machines, provided with some kind of an automatic regulation, are looked upon with most favour. The company mentioned uses a rheostatic device, the movement of its arm being affected automatically, as the voltage (i. e., speed) tends to change. Cars on many roads have been equipped by this company, among which may be mentioned those on the Santa Fe, the Missouri Pacific, the Chicago & Alton, the Baltimore & Ohio, the Southern, and on the Pennsylvania lines west of Pittsburg.

This company was awarded the gold medal at the St. Louis Exposition in 1904.

There are in America at least five other large concerns engaged in promoting this axle-light system. They are:—The United States Light & Heating Company, of New York, having successful installations on the New York Central and the Lackawanna railways, as well as abroad; the Adams & Westlake Company, of New York, having equipments on the Louisville & Nashville and other roads; the Safety Car Heating & Lighting Company, of New York; the Gould Storage Battery Company, of New York, and the Electric & Train Lighting Syndicate, of Montreal, Canada, having equipments on several roads.

These companies were represented at the American Railway Appliance Exhibition in connection with the International Railway Congress held at Washington, D. C., last May. Their systems comprise the common features of a storage battery on each car, as well as an individual generator driven from the axle, and carried on the truck frame. As the generator is supported on springs, and is movable with respect to the axle, it is necessary to employ some form of flexible gearing between the axle and dynamo. It is the different methods of transmitting this power, and the way in which the generator is regulated for the ever-varying speed of the car, that constitute the basis of the various patents which are controlled by the several companies. There is usually provided, also, an automatic reversing switch for maintaining constant the direction of current through the battery, regardless of the direction of the car.

Some of the voltage-regulating devices previously referred to are field rheostats operated by individual motors. In others, the field rheostats are operated by solenoids, the solenoid being energized by the main current, while in still others, the rheostatic arm is pneumatically operated. But all of these moving mechanisms are liable to derangement, especially when subjected to the vibrations of a railway coach.

The simplest of these regulating systems is that of the United States Light & Heating Company. In this there are no gears, rheostats, nor constantly moving parts. The principle is shown diagrammatically in Fig. 1. The generator A is spring-supported from the car truck, and is driven from the axle by a belt. It is shunt wound, and is regulated by means of a device similar to that employed in the Brush constant-current arc machines. In multiple with the shunt field C is connected a pile R of carbon blocks c, which are arranged so as to be pressed together by a lever F when the latter is pulled down by the solenoid M. This solenoid is joined in series with the main circuit of the generator, and with the storage battery P and lamps E. The battery and lamps are joined in parallel, as shown. If the generator, owing to excessive speed, tends to produce too large a current, the lever F is pulled down thereby, compressing the carbon blocks c; their resistance being thus reduced, the current is shunted away from the field C, and this brings the voltage (and hence the current) of the machine back to normal.

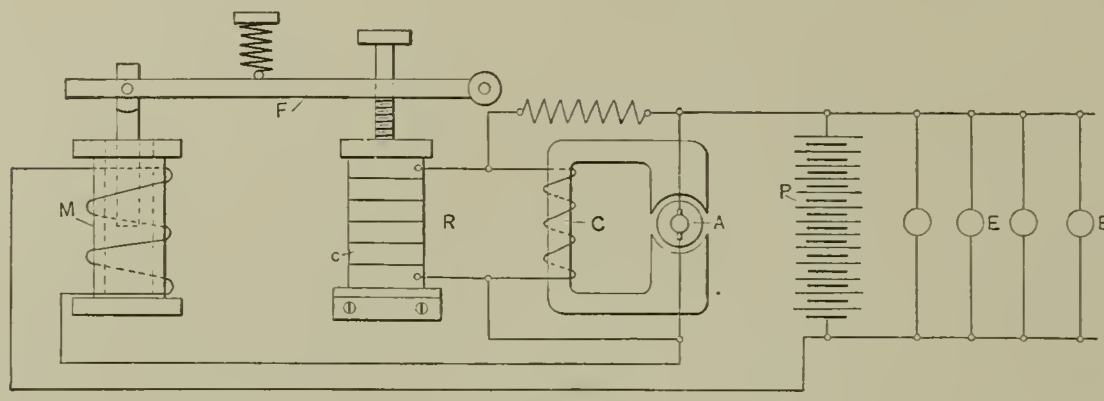


FIG. 1

LOCOMOTIVE HEADLIGHTS

Considering the electric headlight for locomotives, we find that this was successfully tried in Paris as early as 1882. The power was furnished by an axle-driven dynamo. The subject of headlights is merely a specific branch of train lighting, and what has been said concerning the one is largely true of the other. The light itself, consists of an arc light with a parabolic reflector. Attempts have been repeatedly made to furnish current from various forms of axle-driven machines, and also from a separate engine located on the locomotive, with varying degrees of success.

In 1902, the perfecting and introduction of the steam turbine lent a new impetus to both the installation of electric headlights and to electric train lighting. In Prussia, the locomotive carries a steam turbine of from 12 to 20 H. P. directly connected to a shunt generator. The current is used for the headlight, and, in connection with a storage battery on each car, for car lighting. From all accounts, this system seems to give entire satisfaction.

A recent step in the development of the electric headlight has been taken by the Chicago, Milwaukee & St. Paul Railway. Current is supplied by direct-connected, turbine-driven generators running at 2000

revolutions per minute. These machines are differentially wound, so that a short circuit tends to kill the E. M. F., and no disastrous overload is produced. These lights are of 800 C. P., and make the track visible for half a mile. They are also installed on the Southern Railway, the Central of Georgia, and the Cincinnati, New Orleans & Texas Pacific.

CAR SIGNALS

Passing next to car signals, a very large variety confronts us. While there are a number of local appliances, such as means of signaling between conductors and engineer, means for indicating when the doors are open, or the brakes applied, push button stop signals for the use of passengers, etc., probably the most important field in this class is that of the train telegraph. Under this head may be included all means for communicating with moving trains whether by telephone, telegraph, or other device, as well as the cab signals which operate to inform the engineer of his proximity to another train, or to a track signal at "danger." Under this head may also be classed those devices which operate, by electromagnetic means, to set the brakes upon a train under certain predetermined conditions, governed by a track circuit. It may be stated that, although inventors have been very active in devising schemes for carrying out signaling to moving trains, such schemes have, for the most part, been impractical, and, so far as is known to the writer, have not been commercially adopted to any extent. In cases where roads have been induced to install certain of these devices, such installations have been solely experimental.

Naturally, one of the first ideas to suggest itself to experimenters was that of providing an insulated wire or "third rail" along the track, and equipping the locomotive or car with a trolley, or "shoe" to co-operate with it. The rails themselves were used as the return. In this circuit could be included a signaling instrument. Then, too, electrical contacts were placed along the track to act with shoes on the locomotive, the circuit, thus momentarily established, being made to operate a signal, set the air brakes, or perform any desired function. This system could be made automatic by dividing either the track rails or contact rails into blocks or sections, insulated from one another, and equipping each piece of rolling stock with a battery or source of current.

The original idea was that when two locomotives thus equipped ran into the same block, they would mutually act to close each other's signaling circuit, and thus alarms would be given. But it was found that two trains might enter opposite ends of adjacent sections at the same time and meet at an insulation point without giving any signals. To obviate this difficulty the double sectional rail, provided with alternating sections, was devised. From an inspection of Fig. 2 it is obvious that a signal in this case would always be given.

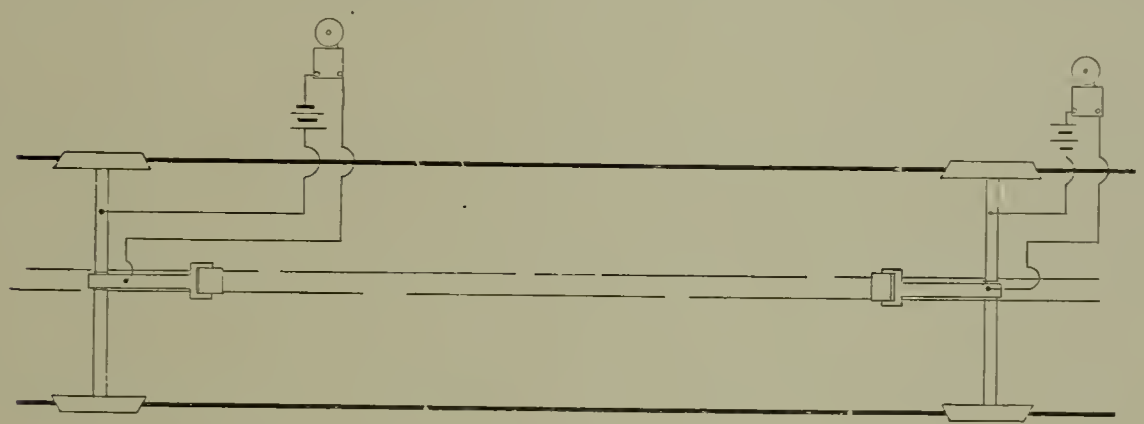


FIG. 2

Seeing that any system of cab signaling employing an auxiliary conductor or third rail of any type was too expensive, it has been the aim of inventors to produce a "wireless" system. By "wireless" in this case, is meant a system employing the track rails only. Such a system necessitates the rails being insulated from one another, is consequently liable to derangement by the weather conditions, and troublesome to maintain. In order to produce both "caution" and "danger" signals in the cab, with such a system a polarized relay is necessary, and, at least, some of the wheels have to be insulated from their axles. This system is being installed on the New York Central Railroad, by the Miller Signal Company, of Chicago.

Passing from the separate conductor with a moving contact carried by the train, the next step in advance was signaling by induction. Edison, Phelps, and others, as early as 1881 conceived the idea of sending impulses along the line adjacent to a track, and having these impulses induce currents in a closed circuit carried on the train. In the Edison device the metallic roof of the car is employed as part of the local circuit. In other systems a single wire is used, stretched lengthwise of the car, while in still others a coil wound on a longitudinal frame is used. In all these systems either alternating or interrupted current is required. A vibrator is usually employed, together with a telephone receiver and a Morse key, as shown diagrammatically in Fig. 3.

This system of induction signaling was really a form of space or wireless telegraphy over the short distance between the track conductor and car conductor. Since the time, however, when Marconi startled the world with his achievements, there have been several efforts to apply the true aerial transmission to train signaling.

Probably the most successful worker along these lines is Francis J. Green, a civil engineer, of New York. In his system each cab is equipped with a Hertzian wave generator and receiver, and, by means of a polarizing device of his own design, he is enabled to employ selective signals of such a nature that

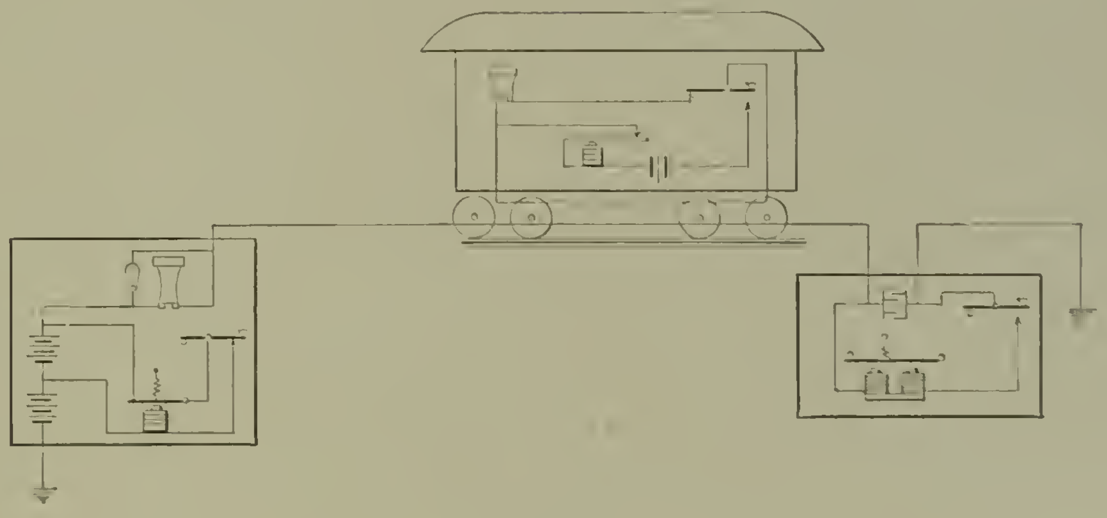


FIG. 3

trains on one track are not affected by vibrations emitted by a train on a parallel track. Following out this selective idea still further, he is en-

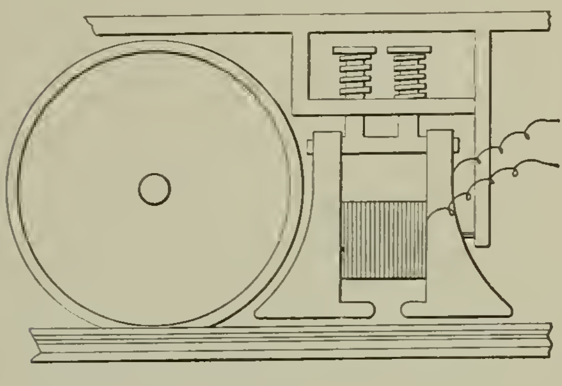


FIG. 4

abled to operate "block" signals, and to so arrange each one in connection with a resonater that as a train approaches it, vibrations are set up which are taken in by a syntonized receiver at the train despatcher's office. Thus, the despatcher is kept informed of the movements of the train. It is understood that this system is being installed on the Chicago & Alton Railroad, and that 768 miles have already been equipped.

ELECTRIC BRAKES

The subject of electric brakes has received attention almost since the introduction of electrical traction in the early eighties, and has achieved considerable commercial importance. It may be here stated, however, that electric brakes have been successfully employed only on electrically driven cars.

As is well known, car motors, when driven (as by the momentum of the car), become generators. It is also well known that the resistance offered by generators to being driven, is proportional to the current passing through them. These principles have been utilized by inventors for braking purposes. Generally speaking, the development has been along four broad lines:—

1. The short circuiting of the motors on themselves.

2. The connecting of the motors to special solenoids which apply the brakes.

3. The operation of such solenoids or magnetic clutches by current from the line.

4. The employment of magnetic brake-shoes.

In the first system the manipulating of the controller is designed to cut off the power current, to reverse the connections of the motors, and to join them up to each other through more or less resistance. The magnetic drag of the armatures, due to the current generated in them, is depended upon to afford the retarding action to the car; the less the resistance in circuit, the greater this action. Some inventor even went so far as to arrange this resistance in coils inside the car, so as to form electric heaters; in this way, each time the car was stopped, the waste energy thus generated was utilized in keeping the car warm.

The second form differs from the first only in that, instead of resistance coils, the current generated by the motors is made to pass through the coils of suitable brake-applying solenoids. These simply apply the brake-shoe mechanically as do the cylinders and pistons of the air systems. All the various clutches, drums, solenoids, and magnets, which exert a mechanical braking action, are combined with proper controlling resistances whereby the effect may be produced gradually, without jar, and, in some cases, whereby that much desired intermittent pressure of the brake-shoe may be obtained.

The third class needs no further explanation.

The fourth class is probably the most practical and commercial. Two kinds of magnetic shoes are employed. One kind is designed like an ordinary shoe, but, on account of being magnetized, produces a better grip on the wheel, preventing slipping; the other variety is designed to exert a magnetic influence on the rail itself. Some depend merely upon the magnetic drag, while others are designed to grip the rail, and rely upon mechanical friction as well. Many forms consist of combined rail and wheel brakes. See Fig. 4.

The Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa., have been very prominent in exploiting the magnetic rail brake, while the General Electric Company, of Schenectady, N. Y., have been scarcely less active in devising other systems of the types already referred to, for electrically controlling and braking electric trains by means of a master controller. Among the prominent names closely identified with this great work, those of Sperry, Potter, Case, and Sprague are most conspicuous.

As these systems of electric braking and heating are, as previously stated, available only on electrically propelled cars and trains, they may be classed as subjects allied with electric traction, and therefore fall a little beyond the scope of the present article.

CAR-CONTROLLED SWITCHES

The use of electricity for automatic switching, so far as is known to the writer, has been confined entirely to electrically operated railways, and finds its best application in street railways. Here switching is frequent, and anything in the nature of a mechanical arrangement, such as an automatic stand, would be out of the question on a crowded thoroughfare.

It has long been the ambition of engineers and street railway men to devise some arrangement to do away with the seemingly inevitable switchman, who, for the last quarter of a century, has stood upon the corner with his hand lever to direct cars to their proper destination. So far, it cannot be said that efforts in this direction have met with much success from a commercial standpoint. There are, generally speaking, but two systems that have been widely brought into notice. These are:—

1. That in which the movement of the switch is effected by manipulation of the motor controller.

2. That in which some auxiliary lever is employed.

The first class is diagrammatically illustrated in Fig. 5. Here, a short section of trolley wire *R*, or a contact strip, is supported in the line of travel of the trolley wheel *T*, and insulated from the rest of the trolley wire. The main trolley wire is made continuous by some type of bridge

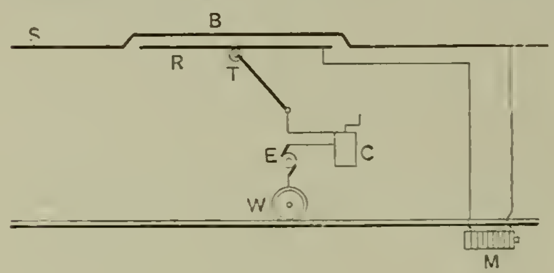


FIG. 5

B. A powerful electromagnet *M* is attached to a mechanical movement for throwing the switch point, and is joined in circuit between the trolley wire *S* and the insulated section *R*. If, upon approaching the switch, the motorman sees it in the proper position, he shuts off power and coasts over the section *R*, but if he desires to throw the switch he runs on to the section *R* with the controller on. Current then flows from trolley *S* over the wires to magnet *M*, section *R*, trolley *T*, controller *C*, motor *E*, to the wheels *W*, thus energizing the magnet *M* and operating the switch.

With devices of this character it is customary to employ a mechanical movement in connection with the switch point, of such a nature that successive energizations of the magnet *M* cause the switch point to move in opposite directions. The Baldwin & Rowland Switch Com-

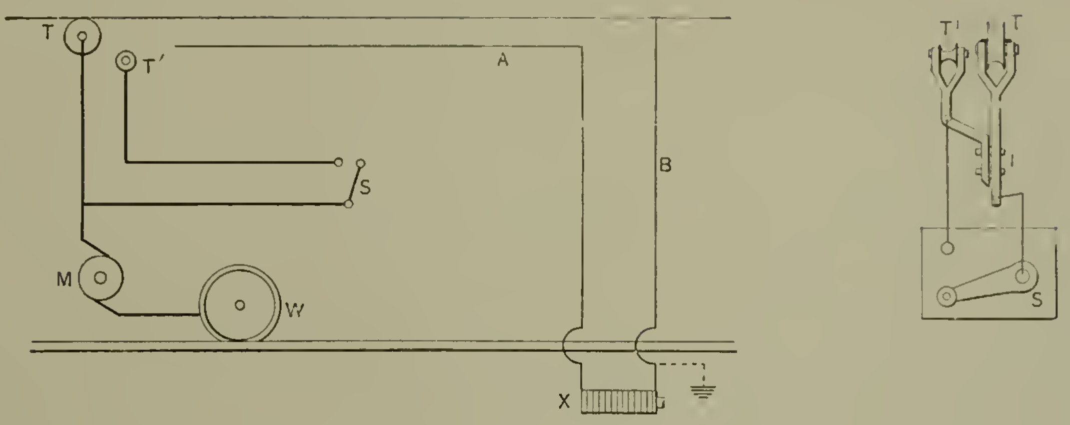


FIG. 6

pany, of New York, have been energetic workers along this line, and have about seventy-five devices in service.

Referring now to Fig. 6 for the other type of device, the main trolley wire is here continuous, and is flanked a short distance in advance of the switch by an auxiliary wire, on which an auxiliary trolley wheel or contact, *T*, is adapted to run. Upon closing the switch *S* current will flow from the trolley wire, through the magnet, section *A*, trolley *T*, switch *S*, to ground. Or, with the arrangement shown in the detail view to the right, the wire *B* would lead from the magnet *X* to ground, as shown in dotted lines in the diagram, and the current would be supplied from the main trolley pole through the switch *S*, as shown. Either a mechanical movement, such as previously described, is employed, or else the switch is normally held in one position by a spring, and in the other by the magnet, the section *A* being long enough to maintain the excitation of the magnet *Z* till the car has passed the switch.

One of the few devices for electrically operating switches which has actually been put in use is that made by the Cheatham Electric Switching Device Company, of Louisville, Ky. Their system is, broadly speaking, of the first type previously mentioned, but embodies a radically new idea. The system is shown in Fig. 7. In line with the main trolley is placed a frame containing insulated contact strips *A* and *B*. These strips are connected to a relay *R*, and to the double solenoid *S* in the track, and are so arranged as to be bridged by the trolley wheel *T*. Suppose current to be shut off from the motors, and that the car simply coasts over the contacts. Current will flow over the wire *P*, relay *R*, wire *Q*, strip *B*, wheel *T*, strip *A*, wire *C*, contact *D*, lower half of solenoid *S* to ground by wire *U*. This current, owing to the resistance of solenoid *S*, is not of sufficient strength to energize *R*. Hence the armature stays down, and current flows through the lower solenoid as described, energizing it and pulling the switch point over.

If, on the other hand, the motorman runs under the contacts *A* and *B* with the controller turned on, this affords a low resistance path to ground, and current rushing through the relay *R*, contact *B*, trolley *I* to ground, energizes the relay and causes it to close the circuit with contact *E*. Current thus flows in shunt through the trolley *I* to contact *A*, and thence over the wire *C*, contact *E*, to upper half of solenoid, and to ground, thus throwing the switch the other way.

This device is in operation on street railways in Louisville, Pittsburg, New York, St. Louis, Memphis, and elsewhere, and is seemingly giving satisfaction. The solenoid and operating parts are enclosed in a water-proof case, in an iron box, and thus are not liable to derangement. Railway companies are, however, slow to take hold of automatic switching devices, owing to the widespread belief that they are not reliable.

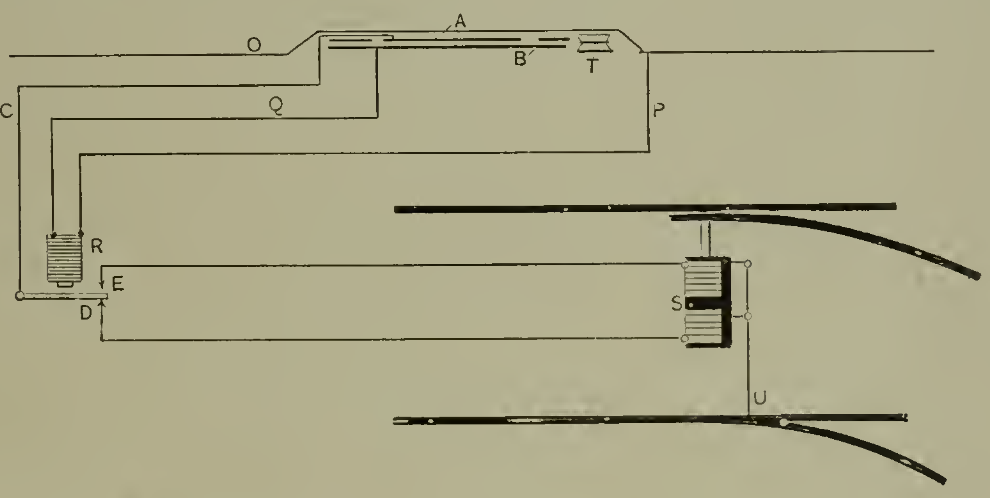


FIG. 7

TOWER-CONTROLLED SWITCHES

This class of devices occupies a vastly more important commercial position than the preceding one. In fact, these devices seem destined to become, in the course of time, indispensible for large railway plants. By tower controlled switches are meant those by which the movements of trains on both steam and electric railways are directed, especially at large stations and terminal yards, and which are controlled and operated from a central stand usually known as the signal tower or cabin.

These remarks, and the rest of this subject apply as well to signals as to switches, because semaphore signals are always employed in yards and plants in connection with the switches, and are operated from the same cabin. In fact, it is customary, to arrange the levers controlling the several switches and signals, in a single group, and to so connect them mechanically as to prevent any two interfering, or contradictory switches or signals being operated at the same time. Such an arrangement is known as an interlocking machine, and is almost universally employed at all cross-overs and large stations. With such an arrangement it is mechanically impossible to set a signal at "clear," for instance, till its corresponding switch has been put in "normal" position.

Up to within a comparatively few years ago, all such switches and signals were mechanically operated by means of wire or rod connection extending from the switch to the lever in the tower. But as the traffic became heavier and the distances from the tower longer, there was need of a power operated device which would make the duties of the signalman less onerous, and effect greater speed and certainty in the manipulation of the traffic controlling devices. The first step in this direction was the application of compressed air motors.

In railway switching and signaling, the all-important thing is certainty.—absolute certainty as to the condition of the apparatus. With a simple motor the operator might admit air from the tower, but would have no way of knowing whether or not the switch had been thrown. Accordingly, it was necessary to provide some

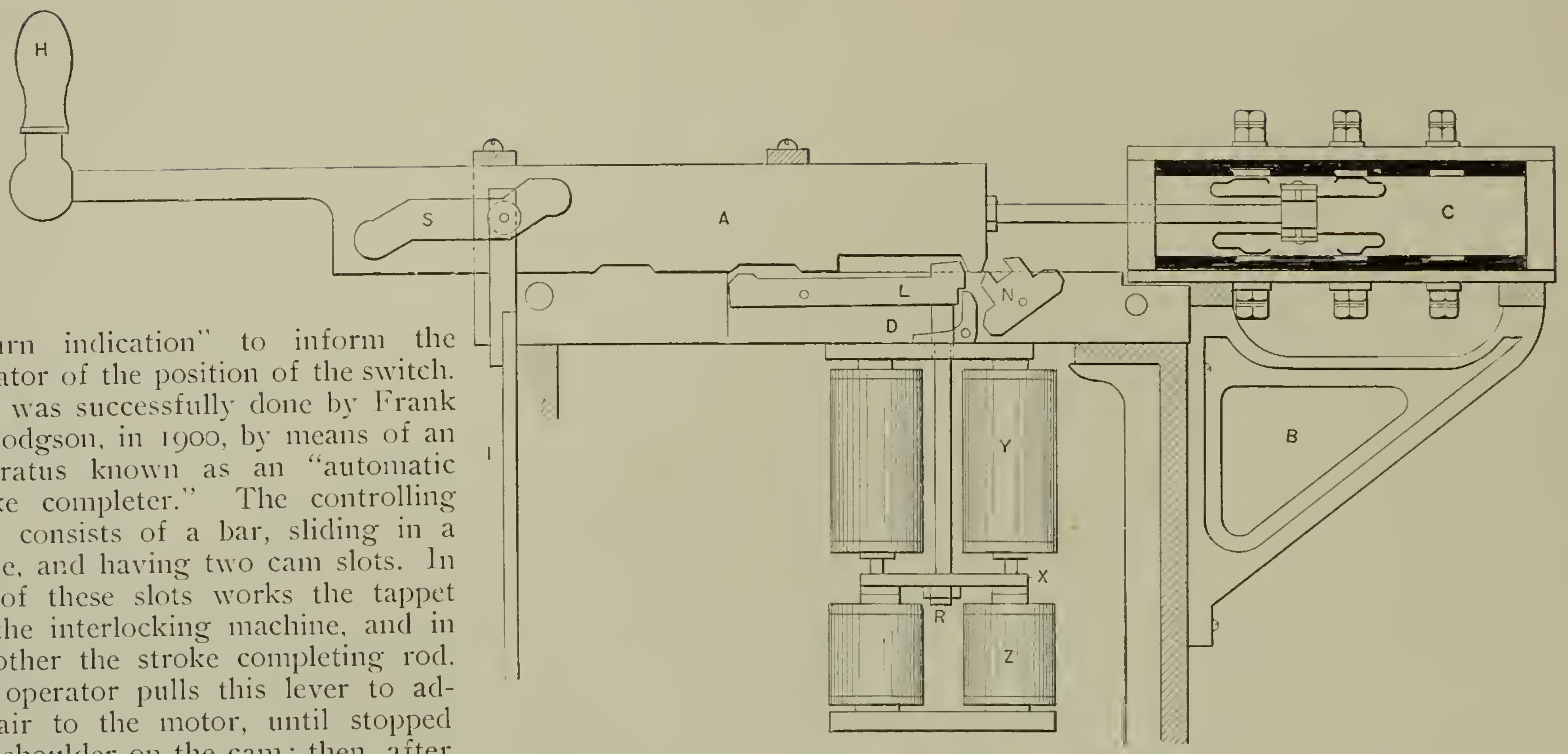


FIG. 8

"return indication" to inform the operator of the position of the switch. This was successfully done by Frank L. Dodgson, in 1900, by means of an apparatus known as an "automatic stroke completer." The controlling lever consists of a bar, sliding in a frame, and having two cam slots. In one of these slots works the tappet for the interlocking machine, and in the other the stroke completing rod. The operator pulls this lever to admit air to the motor, until stopped by a shoulder on the cam; then, after the switch has gone over, air is automatically admitted to a cylinder adjacent to the lever whereby the lever is thrown still further in the same direction, thus completing the stroke and producing the "indication" that the switch has been thrown. Such a system formerly required five pipe lines, but this number has been reduced to three.

As early as 1887, an electro-pneumatic system was put on the market by George Westinghouse. This system does not possess the valuable features of a "stroke completer." The signals and switches are operated by compressed air, the passage of which to the motors is controlled by electrically actuated valves. The function of the levers in the tower, therefore, is that of controlling the electric circuits of these valves. Each lever is provided with a locking magnet, the function of which is to prevent the complete movement of the lever until energized by current in a circuit adapted to be completed by the throw of the switch point, or movement of the signal. When thus energized, this magnet releases the lock and permits the final movement of the lever. This system is, therefore, a "return indication" system, the releasing of the lever being an indication to the signalman that the switch or signal has been properly moved. This Westinghouse system is to-day probably the most widely used power apparatus in existence. It is made by the Union Switch & Signal Company, of Swissvale, Pa., and is used in more than seventy-five plants in the United States, including that at South Station, Boston, which is the most elaborate power interlocking plant in the world.

In the minds of signal engineers, perfection had not yet been reached in this art. Pipes are expensive to lay, and compressed air valves are likely to give trouble. It remained for the all-electric system to solve the problem. One of the best of these, known as the "Taylor dynamic system," can be understood by reference to Figs. 8 and 9. Fig. 8 represents a sectional view of the interlocking machine, and Fig. 9 is a diagram of the circuits embodied in the system.

A series of levers, such as *A*, is arranged side by side in a frame. Each is provided with a locking rod *I* working in a cam slot *S*, by means of which it is mechanically interlocked with other similar levers. Each lever *A* is provided with a handle *H*, and is connected with a controlling switch *C*, which it operates. This is supported on a bracket *B*. The bottom edge of the lever *A* is provided with a series of notches with which the latch *L*, and locking dogs *D* and *N* are adapted to cooperate, and whereby the lever is at times permitted to move, and at other times locked against movement.

Attached to the frame are a pair of electromagnets *Y*, *Z*, known respectively as "indication" magnets, and "safety" magnets. Between the two, works the common armature *X*, carrying a vertical rod *R*. The lever, as shown is in its operating position, having been pulled out till stopped by the latch *L*. When, however, the magnet *Y* is energized, the rod *R* is lifted, tripping the dog *D*, and releasing the latch, thus permitting the lever to be moved to its final position. This releasing is an indication to the operator that the switch mechanism has operated properly.

In Fig. 9, the same reference characters *Y*, *Z*, *C*, etc., have been preserved. The diagram shows the switches and signals connected so as to be operated from the same cabin, the latter being indicated by the heavy broken line.

To operate the first switch, the switchman would throw the controller *C* to the right so as to bridge the middle and the right-hand set of contacts. Current then flows from battery *O* to wire *I*, 2, *G*, 3, safety magnet, *Z*, (thus holding its armature against accidental movement), 4, 5, 6, contacts and controller spring *C*, 7, pole changer *P*, 8, motor armature *M*, *P* again, field *Q*, 9, 10, back to battery. This causes the motor to revolve, and, through suitable mechanism, move the switch rails.

When the switch rails have been moved and locked, the pole-changing switch is automatically thrown. The motor then continues to revolve by its own momentum and acts as a generator. Current then flows from the right-hand brush, pole changer *P*, wire 14, circuit controller *C* (by lower spring), magnet *Y*, right-hand coil of magnet *F*, wires 11, 10, 9, *Q*, *P*, 8, to left-hand brush. Magnet *Y* is thus energized and the indication given.

The magnet *F* has its left-hand coil normally energized from the battery, and the right-hand coil is so wound and connected to the circuit that, should a cross or short circuit exist between any two wires, as indicated by the dotted line 100, the magnet would become neutralized

by the current flowing through the right-hand coil if any attempt be made to operate the faulty unit. This neutralization would result in the opening of switch *G*, thus cutting off the operating current from all the circuits. Current would then flow through the high resistance shunt *E*, and hold open the circuit at *K* till the fault was remedied.

AUTOMATIC SIGNALS

Automatic signals include block signals, switch signals, and crossing signals, but the last two are of minor importance. The switch signals are simple electric indicators, included in a circuit connected with the switch-throwing means (usually manual) to show the position of the switch.

Crossing signals are designed to be placed at highway crossings to warn pedestrians and vehicles of the approach of a locomotive. Usually, they comprise a bell placed at the crossing, electric means for putting it in operation upon the approach of a train within a stated distance, such as half a mile, and other electric means for discontinuing the operation after the train has passed. Such electric means may comprise a relay controlled either by sectional rails, or by a circuit closer operated by the wheels. One of the most widely known and commercially successful systems is that put out by the Railroad Supply Company, of Chicago, Ill. They employ sectional rails, only, and owe their success to what they have termed an "interlocking relay." This relay will close the bell circuit upon the approach of a train from either direction, and will open the circuit when the train passes the bell.

Block systems have for their object the automatic spacing of trains so as to prevent collision. Without going into the mechanical details, it may be stated that such signals have been designed to operate by means of wound-up weights, electric motors, compressed air, and, very recently, liquefied gas, such as carbonic acid, contained in local reservoirs. But whatever the power employed, it is always controlled by means of a relay or electromagnet of some type, which must be included in a circuit under the control of the moving train. This may be accomplished, as already stated, either by circuit closers operated by the wheels, and known as "track instruments," or through the agency of sectional rails.

The original sectional rail idea is illustrated in Fig. 10. The relay *R*, adapted to control, in some manner, the operating mechanism of the block signal *S*, is included in a normally open circuit containing a battery *B*, and the track rails *T*, *T'*, constituting the "block." The block may be several miles in length, and its rails are separated from the adjoining ones by means of insulated joints *C*, *C*. Suppose a train enter the block from the right, the wheels and axles would serve to complete the circuit of the battery through the relay, and thus effect such movement of the signal as would indicate to a following train that the block was occupied; this condition would continue till the circuit was broken again by the train leaving the block. This is known as the "open circuit" arrangement. Its defect is that, should the battery be exhausted or the circuit interrupted, the mechanism would fail to operate, and a wrong signal would result.

To remedy this defect, the "closed circuit" system was devised and patented in 1872, and since then has

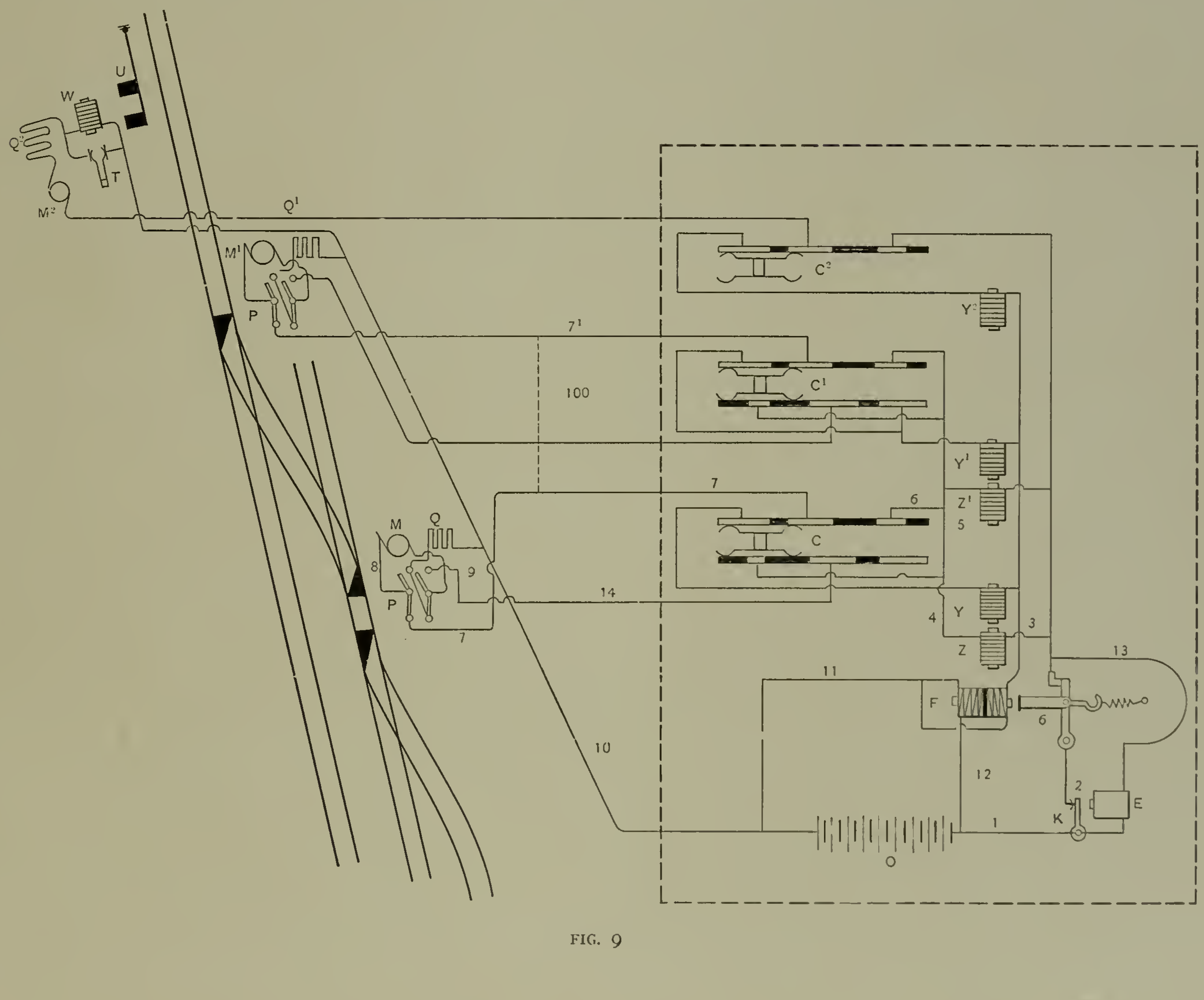


FIG. 9

been widely employed. The arrangement is illustrated in Fig. 11. Here the relay *R*, rails *T*, *T'*, and battery *B* form a normally closed circuit in which current constantly flows to hold the signal mechanism in the position indicating "line clear," or "safety." The mechanism is, therefore, adapted to respond to an absence of current in the relay, in order to move the signal into a position indicating "danger." This usually happens when a train enters the block; then the wheels and axles form a path of very low resistance which practically short circuits the battery, and thus deprives the relay of current. It is moreover seen that, with this system should for any reason the current fail, the signal will go to "danger" and no collision will result.

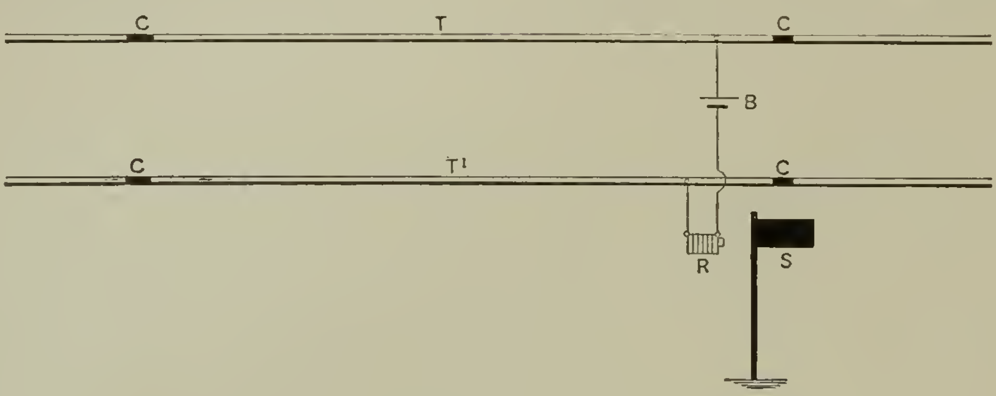


FIG. 10

This arrangement constitutes what is known as the "normal safety" system. In this it is necessary to exert a constant force to hold or lock the signal in the safety position. This force is withdrawn when the relay is de-energized, and the signal being counterweighted, goes to "danger" by gravity. Some power mechanism then is necessary to pull the signal back to safety. The General Electric Company, of Schenectady, N. Y., is a strong advocate of this system, and has on the market a very complete signal apparatus, operated by an electric motor, fed from a local battery, and controlled by a track relay as shown in Fig 11.

Probably the most general usage in automatic block signaling is to employ what is known as the "normal danger" system. In this arrangement the signals are counterweighted, and when free, normally occupy a position indicating stop. The track relays are constantly energized to hold the signal motor circuit open or to exclude pressure from the motive cylinder, as the case may be. If then, a train enters a block and the line is clear, the relay is short circuited and motive power thereby applied to move the signal to the "safety" position. If the battery or circuits should fail, the signal remains in the danger or "stop" position. When a train is in a block, it prevents, by means of an auxiliary relay, a second train clearing the signal of the preceding block.

On continuous block systems it is customary to employ two signals upon a single pole at every block. The signals are known as the "home" and "distant" signals, the first moving to indicate the condition of the block immediately ahead, and the second, that of the second block ahead. It is also customary to control the distant signal of one block by a circuit governed by the home signal of the next block. In this way, whenever a block is occupied, and its home signal indicates "danger," the preceding "distant" signal will indicate "caution." Fig. 12 indicates the condition of affairs in a normal "safety" system with a train on one of the blocks. The second train traveling in block 1 would be advised, by the caution signal, of the presence of a train in block 3.

The first power to be commercially applied to the operation of automatic signals was compressed air. This was successfully done as early as 1881. The first design embodied a pneumatic pipe line along the road, and air cylinders for moving the signals. The admission of air to the cylinders was controlled by electric valves, included in closed track circuits, such as shown in Fig. 11. The objection to a system of this kind is the cost of installing and maintaining a pipe line.

The first use of an electric motor for operating a signal is found in England, as far back as 1884. Electric motor-driven signals are now made by the Union Switch & Signal Company, of Swissvale, Pa.; the Hall Signal Company, of New York, N. Y.; the General Railway Signal Company, of Buffalo, N. Y., and the General Electric Company, Schenectady, N. Y.

At the Railway Appliance Exhibition held in Washington, D. C., in May, 1905, the General Railway Signal Company had on exhibition a normal danger, electric semaphore, the distinguishing feature of which was the track relay. This was designed to operate on one volt; by employing this low voltage in the track circuit, leakage due to a wet roadbed is made negligible. The Union Switch & Signal Company also exhibited a type of electric semaphore, and a new automatic electric semaphore was shown by the Hall Signal Co.

The latest development in the art of automatic signaling is the "liquefied gas" signal recently brought out by the Hall Signal Company. In this system, liquefied carbonic acid gas is stored at 600 pounds pressure in steel cylinders, which are buried in the ground adjacent to each signal. The gas is allowed to expand little by little into an auxiliary chamber, whence its passage to the motive cylinder is controlled by an electric valve, in the usual manner.

In connection with automatic signals it is becoming more and more common to employ devices known as "automatic trips," the object of which is to automatically stop a train, should it attempt to run past a danger signal. The result is accomplished by providing a lever on the rolling stock, connected with the air brake system and with the power supply, and designed to be struck by

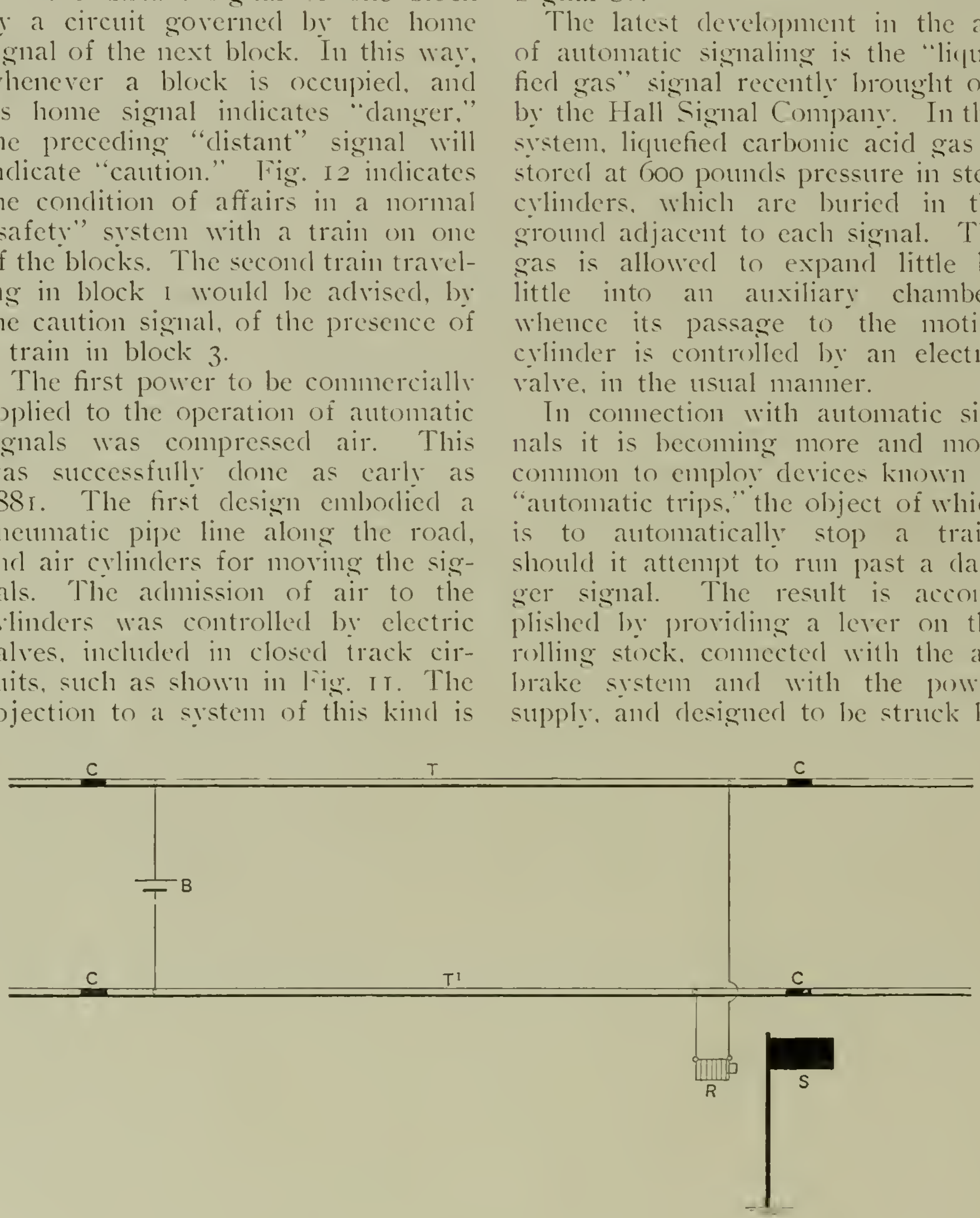


FIG. 11

a tripping lever arranged on the track, adjacent to the signal. This tripping lever is so connected with the signal as to be moved into an operative position when the signal indicates danger, and to an inoperative position when the signal shows safety. Such connection may consist of a mechanical coupling, or in having the track circuit control the trip and signal in common, or having the same track relay control valves for admitting pressure to both trip and signal cylinders. This system may be applied either to electric or steam roads.

The most thoroughly up-to-date equipment embodying the block system, with automatic stops, is that in the New York Subway. This road was completely equipped by the Union Switch & Signal Company, but it is understood that Frank E. Kinsman, of the Kinsman Automatic Block Signal Company, of New York, has brought suit against them for alleged infringement of some of his earlier patents relating to automatic stops. The trips and signals are operated by means of compressed air, which is supplied through pipe lines from motor-driven compressors. The supply of this air to the motive cylinders is controlled by electric valves. The circuit for these valves is, in turn, controlled by alternating-current relays, connected to the track circuits. The reason for using alternating current on the track circuit is to prevent possible false operation by leakage, from the direct current used for propelling the cars. Since the track has to serve as a return conductor for the direct current, one rail is utilized for this purpose, while the other rail is divided into insulated sections for connection with the track relay. The trip lever is elevated by compressed air, whenever the adjacent signal is at danger, and the cars are equipped with automatic controlling devices whereby the power circuit is broken and the brakes applied, should a car attempt to run past a signal set at danger.

A very common application of the block signal system is found in suburban trolley roads. Here single tracks are largely employed, with sidings at intervals, for passing, and it is customary to provide signals at both ends of a single section or "block." These signals usually consist of coloured electric lamps, fed direct from the trolley current, and provided with such circuits and controlling devices that a lamp at each end of the block is automatically lighted when a car enters the block, and extinguished when the car leaves the block. The circuits of the lamps are usually controlled by switches located adjacent to the trolley wire, and actuated by the mechanical contact of the trolley wheel as it passes.

Prominent engineers have recently been engaged in developing a new system which is a radical departure from anything heretofore devised.

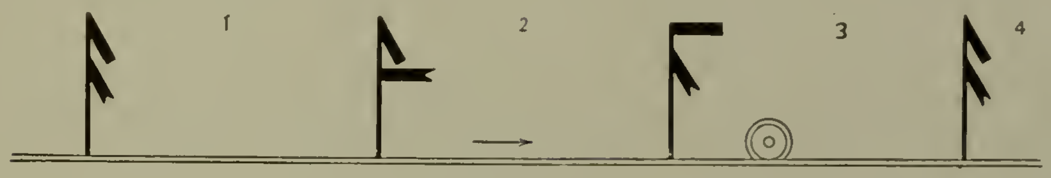


FIG. 12

This new system contemplates, broadly, the transmitting of both direct and alternating currents over the same conductor, and, by suitable devices, segregating them, and causing each to perform only its own function. The arrangement is shown diagrammatically in Fig. 13. Alternating and direct-current generators *A* and *D* are connected to the same feeder *F*, the former through a condenser *C*, and the latter through an inductive resistance *R*. The alternating current is practically incapable of flowing through a high inductive resistance, and the direct current is effectually insulated by a condenser, which, however, transmits the alternating current freely. The trolley wire sections are fed through reactance coils from the feeder, and alternating current, and with a shunt containing a condenser, to transmit the alternating current.

As in the case of the New York Subway, it is seen that with this system, it is impossible for the relays to be accidentally actuated by stray currents from the power circuit, as they respond to alternating current only. This use of the alternating-current relay is now forming the subject of some animated legal fights in the U. S. Patent Office. The writer believes that this instrument will form the basis of the signal systems of the future.

TOWER-CONTROLLED SIGNALS

Several of the more important types of tower-controlled signals have already been discussed under "Tower-Controlled Switches," being inseparable from them. There are, however, two other types, known respectively as the "lock and block" system, and the "staff" system.

The "lock and block" system is probably the oldest form of absolute blocking in existence. It is an elec-

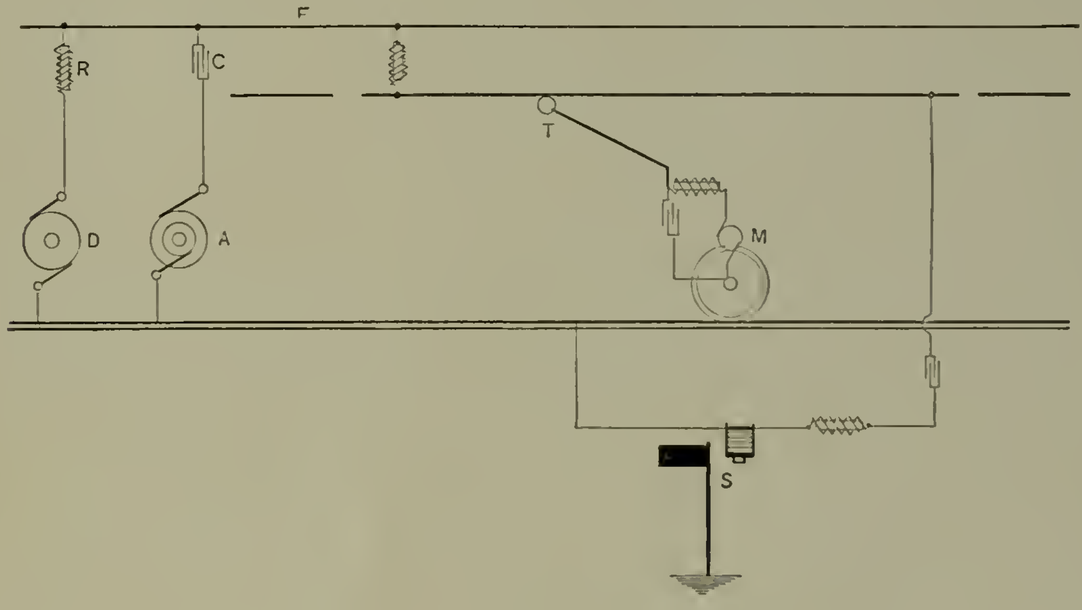


FIG. 13

each section is connected through a condenser and signal controlling relay, to the rails. The condenser excludes the direct current, and a small reactance is included to prevent an excessive flow of alternating current through the relay. The relay, when it is short circuited by a car entering the section, actuates the signal in the usual manner. The cars are provided with heavy inductance coils in the motor circuit *M* to exclude the

tromanual system, operated manually from the tower, but controlled electrically from a distance, usually from the next station. The road is divided into "blocks," with a signaling station at each end. This system is the next step in advance over the primitive telegraph block. Given two stations, *A* and *B*, with an intervening block of track, *A's* signal is cleared by hand for a train to enter the block, and run to *B*. After

the train has passed *A*, he returns his signal to "danger," in which position it is automatically locked, by electromagnetic means controlled by the presence of the train in the block. *A*, therefore, cannot move his signal to "clear" for a second train, till the first train has left the block, and the first train cannot leave the block until permitted to do so by *B*.

In other forms, the continuous-rail circuit is dispensed with, and the locking of *A's* signal is controlled entirely by the condition of affairs at *B*. *B*, of course, will not allow *A's* lever to be unlocked until *B* has seen that the train has left the block, and all is clear. It is customary to provide an electric bell signal in connection with this system, by means of which, and a suitable code, communication may be had between the two stations. It is also customary to provide an automatically movable dial or indicator, actuated by electromagnets, and controlled by circuits having suitable connection with the actuating levers, and bearing legends such as "train in block" and "line clear," whereby the operators at each end are kept informed as to the condition of the block.

This controlled manual "lock and block" system has been installed on the New York Central, the New York, New Haven & Hartford, and on the Erie Railroads. It is used very extensively abroad, but in this country seems destined to be replaced by the automatic block.

No treatment of this subject, however brief, would be complete without some reference to that widely used device known as the "electric slot." It is employed quite generally in connection with controlled manual systems, and such signals, when so equipped, are known as "semi-automatic." Generally stated, the "electric slot" is a mechanism which, when applied to a manually operated or controlled semaphore, causes it to automatically go to the "danger" position whenever a train enters the block controlled by it. More specifically, it consists of an electromagnetic means forming the connection between the semaphore and its actuating means, whereby, when the electromagnet is energized, it rigidly couples the semaphore with its actuating means, but when de-energized permits the semaphore to have independent movement. This electromagnet is included in a circuit which is governed by an ordinary closed-circuit track relay.

If, therefore, a careless signalman has left his signal locked in a "clear" position behind a train, the train entering this block acts upon the relay, causing the de-energization of the electromagnet; this disconnects the signal from the controlling lever, and, being counterweighted, it automatically assumes the danger position.

The staff system, in its original conception, dates back almost to the beginning of railroading. The idea was first used in England. In order to give a train the right of way over a stretch of single track, the engineer was presented with a stick or "staff" which he carried to the next station. A train desiring to run in the opposite direction had, therefore, to wait for the staff at this second station, it being against the rules for any train to proceed without it. Thus, head-on collisions on single-track roads were made impossible. The device was particularly useful between the two ends of a long bridge.

As traffic increased, this primitive system became inadequate, and the elaborate electric systems of to-day were gradually developed. In this country, the electric train staff system has reached a high state of perfection. In the Railway Appliance exhibit previously referred to, the Union Switch & Signal Company exhibited two complete instruments with connecting line, in operation. These systems may be classed as "absolute," or "permissive," the former allowing but one train in a block, the latter permitting several trains to travel in the same direction.

The "staff" consists of a metal rod about 6 inches long, provided with grooves having a definite location and configuration, whereby it can be inserted only in an opening of the same configuration, and can be locked in it. Generally speaking, the staff system comprises two instruments, one at each end of the block, and suitable lines connecting them. These instruments are frames for holding a number of staffs, equipped with electromagnetic devices for at times locking such staffs in the frame, and at other times allowing them to be removed, one at a time. In the absolute system the mechanism of the two instruments is in synchronism, and the removal of a staff from either one, locks both of them, so that no other staff can be removed from either end till the one taken out at the entrance end has been placed in the instrument at the leaving end. This insures the presence of but a single train on a block. Like the "lock and block" system, this system is equipped with call bells, and with indicators of "staff in," "staff out;" to remove a staff requires the co-operation of both operators.

In the "permissive" system, any desired number of staffs may be drawn from the instrument at one end, but it is necessary that the same number be replaced in the instrument at the other end before an opposing train is allowed to proceed.

While as here outlined, wonderful progress has already been made, still greater things are yet to come. In railroading it is pre-eminently true that the thoughts of to-day are the deeds of to-morrow. The development of wireless telegraphy and the better understanding of the nature of alternating currents will, the writer believes, work greater changes in the next decade than even the last has witnessed, and will achieve results hitherto undreamed of. It would not be surprising if we lived to see the electromagnet and primary battery of our fathers, relegated to the museum, and the transmission of controlling power, as well as of intelligence, accomplished solely through the agency of vibrations of the all-pervading ether.

Electricity in Spanish Spinning Mills

THE utilization of electric energy for power purposes in the spinning mills of the Marquess of Larios, at La Aurora, and La Industria mills, at Malaga, in Spain, recently installed, according to "The Electrical Engineer," of London, has been attended with some interesting results. At La Aurora mills the substitution of steam engine driving gear and belting by electric motors driving direct on to the line shafts has reduced the power consumption by 40 per cent. Furthermore, the steadier drive obtained from the motors has increased the yarn production by 20 per cent., owing to the avoidance of yarn breakages. The mills at Malaga are equipped with 72 motors, aggregating 2350 H. P. for three-phase current, and range in power from 15 H. P. to 150 H. P. The average efficiency is 91.1 per cent., and the average power factor 88.1 per cent. The electrical energy is transmitted a distance of about 20 miles at a pressure of 25,000 volts.

It is reported that a company has been organized for the purpose of acquiring the right to use the Marconi system of wireless telegraphy in the Argentine Republic and in Uruguay. The prospectus announces that "the patents of the Marconi Wireless Telegraph Company, Ltd., and of the Marconi International Marine Communication Co., Ltd., have been acquired for the Argentine Republic."

A Typical Berkshire Hydro-Electric Plant

By H. S. KNOWLTON

THE WATER RUNS TO THE POWER HOUSE OF THE WORONOCO PAPER COMPANY THROUGH A STEEL PENSTOCK 550 FEET LONG, BUILT IN SECTIONS AND SUPPORTED ON REINFORCED CONCRETE PIERS

ALTHOUGH the development of hydro-electric power transmission during the past decade has been confined to no single section of the United States, the most striking examples of engineering achievement have mainly been undertaken and consummated in the Far West. The usual long distance of the power market in the West from the generating plant has necessitated the use of voltages far in excess of anything found in the East. The topography also of the country in California, Colorado and other States traversed by great mountain ranges has naturally emphasized the high hydraulic head as contrasted with the moderate water-falls of New England and the Appalachian slope in general. In the Far West, power transmissions at from 40,000 to 60,000 volts are now standard practice, with an upward tendency toward 80,000 and possibly 100,000 volts in the near future, while hydraulic heads of from 1500 to 2500 feet present few obstacles to the turbine and pipe line designers of the present day.

The industrial side of power transmission, however, is much the same, whether the work be undertaken in the West or in the East. However widely the technical details of a given transmission in Colorado may differ from the engineering particulars of a power scheme in New York or Massachusetts, the problem is, in the last analysis, a financial one in every case. Whether the transmission distance be 200 miles or 200 feet, it is equally essential that the project shall pay an adequate return upon the investment, which in its broadest sense implies reliability of service, high operating economy in the unit-cost-of-power production, distribution, and utilization, uniform supply pressure upon the electric circuits, and safety to employees and customers no less than dividends to stockholders. While the use of a line potential of 60,000 volts in California involves construction and maintenance problems of the most serious character, the failure of a 13,000-volt line in New England, supplying power for railway, lighting, and general motor service in a town of a few thousand inhabitants half a score of miles away from the water-fall, means precisely the same relative economic loss in terms of inconvenience and financial embarrassment per customer as in the larger system. Reduced to the mile basis as the unit of measurement, the Eastern and the Western transmission losses and economies form interesting parallels.

In like manner, the economic principles bearing upon the generation of power in a plant located within a stone's throw of its market are of the same relative importance as the considerations which obtain in the commercial supply of power over greater distances. There is as good an opportunity for the practice of expert engineering in the development of a power scheme for a factory supply, practically at the point of generation, as there is in the layout and execution of plans for a system covering 125,000 square miles.

The power plant of the Woronoco Paper Company, at Woronoco, Mass., presents an interesting example of an economically designed layout for industrial service at the point of generation. Woronoco is a small village located near Westfield, in the heart of the Berkshires, the main industry being that of the paper company mentioned. The mill buildings are located on the south bank of the Westfield River, a few hundred yards east of the main line of the Boston & Albany Railroad. A reinforced concrete dam built across the river opposite the mills impounds water enough to operate the plant about 48 hours when flashboards are used.

Below the dam, the Woronoco Paper Company built its power house, the water supply passing through a steel penstock about 550 feet long in sections and supported on reinforced concrete saddles or piers spaced 14 feet apart on centers. The thickness of the penstock varies from $\frac{5}{8}$ inch to $\frac{7}{8}$ inch, and the inside diameter is 11 feet. The penstock is provided with two relief vents, each 36 inches in diameter. The sluice gate is 4 feet by 6 feet in section, and the bottom gate through which the water flows has a cross-section of 2 feet by 3 feet.

The water power is employed for driving water wheels and dynamos, the power and lighting of the mill being electric. The normal head of water upon the wheels is 53 feet; when flashboards are used it is 56 feet. At the top of the penstock a sleeve is provided to take care of

GENERAL VIEW OF THE MILLS OF THE WORONOCO PAPER COMPANY, WORONOCO, MASS. THE STEEL PENSTOCK IS SHOWN AT THE LEFT OF THE ILLUSTRATION

expansion and contraction. The run from the intake at the dam to the power house is of straight pipe, a right-angled elbow being provided at the latter point to turn the water into the wheel casings. This is anchored into the concrete.

The power house is a single-story building with solid concrete foundations, brick walls and a cinder concrete roof. All the machinery is installed in a single room, 56 feet long and 72 feet wide, with a wheel-pit beneath the turbines. Two turbines are installed at present, with space for a third provided. Each of these units consists of a single pair of wheels, mounted on a horizontal shaft and set in a steel case. They are guaranteed to develop 520 H. P. under 50 feet working load, at a speed of 400 revolutions per minute. The feed-water for each pair of wheels comes through the end of the case. They are of the central discharge type, each pair discharging into a common center case and draft tube. The flume or outer case for each pair of wheels is 7 feet in diameter, and the shells are of steel boiler plate, the head of the case at the coupling end being of cast iron.

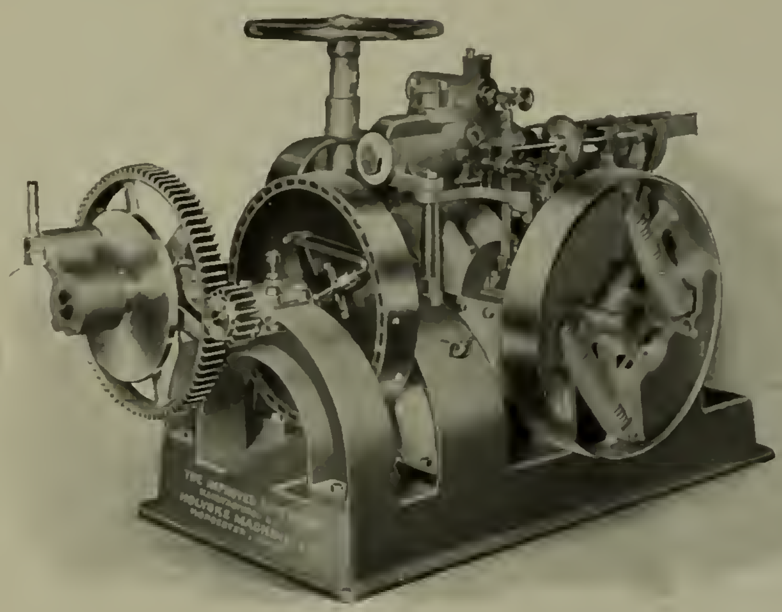
The elevation of the wheel shafts is approximately 17 feet above the level of tail water. The gates are operated by the draw-rod system, which brings all the gearing necessary to operate the gates outside the wheel case, where it is not subjected to the rusting and wearing action of the water. All the gears are machine cut. When a third pair of wheels is installed, the total development will aggregate 1560 H. P. under a 50-foot head.

Between each pair of wheels and the main feeder is installed an 84-inch wicket or butterfly gate, which enables the water to be shut out of one pair of wheels while the other pair or pairs are running. Each of the wicket gates is equipped with a special locking device designed by James F. Bush, treasurer of the Woronoco Paper Company. The locking device wedges the gate tightly against its seat and prevents the leakage which would otherwise result from the bending of the plates under the water pressure acting upon the leverage existing.

Each pair of wheels is connected directly to a 300-KW., 40-cycle, three-phase, 600-volt alternator, built by the General Electric Company, of Schenectady, N. Y. On an extension of the generator shaft is mounted the exciter, which, for each alternator, consists of a 21-KW., 125-volt generator. At one end of the room is a handsome switchboard of blue Vermont marble, containing two generator panels, two exciter panels, one regulator panel, one blank panel, one power panel, and one panel for outside power measurement, in case it is desired later to sell current. The wheels are equipped with both indicating and recording tachometers.

One pair of wheels is governed by a Lombard governor and the other pair by a new "Improved" governor, built by the Holyoke Machine Company, of Worcester, Mass. This governor's most marked characteristic is the uniformity with which the speed is controlled. It is easy to start and stop, and is free from the complication incidental to the use of oil pressure, with the necessity for a vacuum. This relieves the men in charge of a great deal of care. The recording tachometer at Woronoco shows practically no variation in speed, although the load varies constantly. Only a light water pressure is required to handle the heaviest gates; there are no dash pots to get out of adjustment due to changes in the temperature of the oil, etc., and the machine has but one belt. The governor gate shaft may be arranged to open the gates in four, six or eight turns, and the governor is capable of exerting a pressure ranging from 25,000 to 50,000 foot-pounds on the governor gate shaft. Both the governors are controlled normally from the switchboard when desired.

From the power house, current is carried to the mills through an underground line consisting of cables run in tile duct laid in concrete. The



ONE OF THE GOVERNORS IN THE POWER HOUSE OF THE WORONOCO PAPER COMPANY. BUILT BY THE HOLYOKE MACHINE COMPANY, WORCESTER, MASS.

INTERIOR OF THE POWER HOUSE, SHOWING A 300-KW. UNIT AND EXCITER. THE GOVERNOR SHOWN IN THE ILLUSTRATION ABOVE IS ALSO SHOWN HERE

THE POWER HOUSE OF THE WORONOCO PAPER COMPANY

A CLOSER VIEW OF THE POWER HOUSE. CURRENT IS CARRIED TO THE MILLS THROUGH AN UNDERGROUND LINE, CONSISTING OF CABLES RUN IN TILE DUCT LAID IN CONCRETE

mill distribution switchboard is about 600 feet from the power house. This is located with appropriate switches and wattmeters for each department in a small room near the east end of the principal mill building.

All the motors are of the General Electric Company's induction type, operating at about 550 volts, 40 cycles. There are eleven motors of 20 H. P. or more, and the largest motors are two 200-H. P. machines. These induction motors are in some cases direct connected and in others belted to the machinery which they drive. Paper mill conditions are very severe as regards moisture, and there is no doubt that the induction type is far less subject to annoying derangement than any other motor which could be installed. In fact, the experience of induction motor users in paper-mill work is so satisfactory that many mill owners will consider no other type.

An interesting point about the Woronoco power plant is that it was designed in its entirety by Mr. Bush, without the aid of any outside firm of electrical or mechanical engineers. The installation proceeded under his personal direction on the basis of day work, the whole task being regarded in the nature of a thoroughly enjoyable recreation by its director, in the midst of his duties as a paper mill executive. As it stands completed to-day, it represents a straightforward installation characterized by compactness of power units, ample light and space for power house operation, an air line penstock route, and a reliable system of electrical distribution.

Careful records are kept of the gate openings, exciter volts and amperes, and generator outputs, as well as wattmeter records at the mills. Mr. Bush is therefore able to determine exactly what his power is costing him at regular intervals, in each department of the complex process of high-grade paper making. In case the electrical supply should give out, an auxiliary steam engine equipment is available. The use of hydro-electric power for the operation and lighting of these mills is an important factor in the economy of production of the Woronoco Paper Company.

Electrically Dried Peat

FOR the purpose of obtaining a hard combustible, well adapted for use under boilers, an electric process recently adopted in England, says "The Iron Age," requires two and one-half hours and yields a material of high calorific value, almost smokeless, and less expensive than ordinary coal. The basis is peat, which is placed in revolving cylinders, and the water (originally 80 per cent.) is largely driven off. A set of electrodes in the cylinder uses the mass of peat as a part of the circuit. The passage of the current warms and dries the peat, but without carbonizing it, and pulverizes it for the next stage in the process. The peat is then treated by a kneading roller and placed under an automatic press, which forms it into briquettes. It is then stored for final drying.

At the end of 1904, the total capital invested in British electricity supply stations had increased from $40,000,000 in 1896, to $310,000,000.

Electric Power from Blast-Furnace Gas

By H. FREYN, Engineer of the Gas Engine Department of the Wellman-Seaver-Morgan Co., Cleveland, Ohio

From a Paper Read Before a Recent Meeting of the Western Society of Engineers, Chicago

THE following calculation has been made assuming a new blast-furnace plant of two 400-ton blast furnaces, situated in the immediate vicinity of a large city and having the ordinary facilities for water supply and for handling the raw and finished material. Assuming both furnaces in good operation, and assuming a coke consumption of 1900 pounds per ton of pig iron, there will be required 800 × 1900 = 1,520,000 pounds of coke per day. This quantity of coke produces approximately 110,000,000 cubic feet of gas in 24 hours, or, per ton of pig iron, 110,000,000 ÷ 800 = 137,000 cubic feet of gas. The losses on the top of the furnaces may amount to approximately 5 per cent., so that 130,000 cubic feet of gas per ton of pig iron produced in 24 hours could be obtained. The average heat value of this blast-furnace gas will be about 90 British thermal units per cubic foot. The total quantity of gas available for the various purposes in this blast-furnace plant amounts to 130,000 × 800 = 104,000,000 cubic feet of gas per 24 hours, or 4,350,000 cubic feet per hour, having a total heat value of 391,500,000 British thermal units.

Modern double-acting gas engines of large capacity working on the 4-cycle or Otto principle, built with the latest improvements and using high compression of mixture, consume less than 9000 British thermal units per brake horse-power per hour at full load capacity. The total quantity of gas produced by two blast furnaces of 400 tons capacity each, when used in gas engines for generating power, would operate at least 391,500,000 ÷ 9000 = 43,500 horse-power per hour. If, therefore, all the gas generated by a blast-furnace plant could be used for producing power, there would be available over 50 horse-power per ton of pig iron produced per 24 hours.

This quantity of 4,350,000 cubic feet of gas per hour will be divided for the various purposes of the blast-furnace plant as follows:—One part of the gas is used for heating the hot blast stoves, another for operating gas blowing engines, and there is gas required for the auxiliary machinery, such as pumps, hoists, coke and ore-handling machinery, power transmission, compressed air, pig iron casting machinery, and for lighting the entire blast-furnace plant. Some of the gas is also necessary for operating gas engines serving the gas cleaning plants and a certain percentage may be counted for losses in the piping, in the engines, the gas cleaning plant, etc. It will be seen that the total quantity of gas necessary for the operation of the blast-furnace plant itself amounts to approximately 50 per cent. of the total quantity generated, leaving a little less than 50 per cent. available for useful work outside of the blast-furnace plant itself.

GAS REQUIRED FOR HEATING THE BLAST

It is generally figured that about 30 per cent. of the total quantity of gas generated by the blast furnace is required for heating the blast, although this quantity varies considerably according to the quality of the gas, the design and construction of the hot blast stoves and according to the conditions of operation of the blast-furnace plants in general. For European blast-furnace plants the figure of 45 per cent. is found frequently in reports endeavoring to determine the available power from blast-furnace plants, while in this country the gas necessary for the stoves is estimated in certain instances to be as low as 20 per cent. of the total quantity produced.

Edward A. Uehling, in his paper entitled "The Blast Furnace as a Power Plant," determined by a very careful calculation that the quantity of gas necessary for heating the blasts amounts to about 18 per cent. of the total quantity of gas. Other authors assume this quantity to be about 25 per cent. of the total gas for an average blast-furnace plant in the United States.

Assuming 30 per cent., we are certainly on the safe side, and so much more so, since in a new blast-furnace plant all the gas leaving the top of the blast furnaces would be subjected to a cleaning process, thus removing the bulk of the dust carried along by the gas. The question of cleaning the blast-furnace gas which is required for the hot blast stoves and the boilers in a blast-furnace plant has not as yet received as much attention in this country as it has in Europe, where most of the large blast-furnace plants have been equipped in the last two or three years with extensive gas washing plants, cleaning practically every particle of gas produced by the furnaces. Very exhaustive tests as to the advantage of cleaning the gas for stoves and boilers have been made by Emil Hiertz, superintendent of the blast furnaces of the John Cockerill Company, of Seraing, Belgium.

As far as gas consumption of the hot blast stoves is concerned, he found that by using clean gas the temperature of the stoves could be increased at least 200 degrees F., and it will be seen at a glance that this fact tends to decrease the quantity of gas necessary for obtaining a certain temperature in the hot blast stoves, so that in the future the percentage of gas to go into the stoves will be materially decreased. Assuming the figure of 30 per cent., the total quantity of gas necessary for heating the blast will be 4,350,000 × 0.30 = 1,305,000 cubic feet per hour.

GAS BLOWING ENGINES

The new blast-furnace plant of the future will be equipped with just one steam blowing engine for starting the blast furnaces, unless gas producers should be installed, while the rest of the blowing engines will be operated by gas engines. The quantity of blast required will be 90 cubic feet per minute per ton of pig iron produced, or for 800 tons, 800 × 90 = 72,000 cubic feet of blast per minute.

Assuming that all the necessary blast be furnished by gas blowing engines, the latter will normally have to compress the blast to about 15 to 18 pounds per square inch; but

as it will be occasionally necessary to blow against a pressure of 30 pounds per square inch, the gas blowing engines must be large enough to do this work. Figuring on a maximum pressure of about 30 pounds per square inch, the work necessary to compress 100 cubic feet of air against this pressure for adiabatic compression will amount to 8.65 horse-power theoretical, or nearly 10 brake horse-power in the gas engine. As 72,000 cubic feet per minute have to be compressed, 720 × 10 or 7200 brake horse-power in gas engines must be provided for. The engines would, under these conditions, operate under full load. The heat consumption, as stated before, will be less than 9000 British thermal units per brake horse-power per hour. (Actual tests on a double-acting tandem Cockerill gas engine show a heat consumption of 8880 British thermal units per brake horse-power per hour). But assuming 9000 British thermal units per brake horse-power per hour, 1 brake horse-power hour will require 9000 ÷ 90 = 100 cubic feet of gas, and 7200 brake horse-power in blowing engines will therefore require 720,000 cubic feet of gas per hour.

As previously mentioned, under ordinary conditions, the gas blowing engines will have to blow against only 15 to 18 pounds pressure. Taking the lower figure of 15 pounds per square inch, there will be required 5.125 horse-power per 100 cubic feet of blast theoretically, or approximately 6 brake horse-power per 100 cubic feet in the blowing engines. For the total quantity of blast of 72,000 cubic feet per minute, there will be required 720 × 6 = 4320 brake horse-power. The gas blowing engines are supposed to be ample in size to give a maximum of 7200 brake horse-power. They would operate normally, therefore, on 4320 × 100 ÷ 7200 = 60 per cent. of their full load capacity.

The above mentioned test made on a 1500-H. P. double-acting tandem gas engine, built by the John Cockerill Company, of Seraing, Belgium, shows a heat consumption of 10,800 British thermal units per brake horse-power per hour for the engine running at two-thirds of its full load capacity. According to a curve plotted from the above tests, the engine running at 60 per cent. load would show a heat consumption of about 11,100 British thermal units per brake horse-power per hour. Let it be even 11,500 British thermal units per brake horse-power per hour, at 60 per cent. load of the engine, then the amount of gas required would be 11,500 ÷ 90 = 128 cubic feet per brake horse-power per hour, making the total requirements for blowing engines equal to 4300 × 128 = 550,000 cubic feet per hour.

This quantity is less than the quantity required at full load by about 170,000 cubic feet per hour. In other words, 720,000 cubic feet of gas for the purpose of gas blowing engine is the maximum that would ever be required.

AUXILIARY MACHINERY

The power necessary for lighting the plant, for pumps, hoists and all the necessary machinery for operating the blast-furnace plant could be assumed to be about 1.5 brake horse-power per ton of pig iron produced per day. This figure will take into account all the modern machinery with which an up-to-date blast-furnace plant is equipped, and is certainly very conservative, as other authorities estimate the auxiliary power to be far less.

A. Ernst gives the figure of 1 horse-power per ton of pig iron produced; Edward Uehling gives about 1.04 horse-power; W. Oswald, of Coblenz, gives 1 horse-power, and the John Cockerill Company about 1.05 horse-power per ton of pig iron produced. At the rate of 1.5 horse-power per ton of pig iron for auxiliary machinery, the total requirements for the blast-furnace plant of 800 tons will amount to 800 × 1.5 = 1200 brake horse-power. If this power be generated by gas engines and assuming a gas consumption of 100 cubic feet per brake horse-power-hour, the total quantity of gas to be deducted for auxiliary power purposes will be 1200 × 100 = 120,000 cubic feet.

GAS CLEANING

It has been already indicated that a modern blast-furnace plant will be equipped in the future with extensive gas cleaning apparatus to cleanse all the gas produced by the furnaces. Aside from the advantage of obtaining a higher temperature in the hot-blast stoves, thus decreasing the quantity of gas necessary for heating the blast and eventually decreasing the coke consumption per ton of pig iron produced, there is a decided advantage in using clean gas for heating the stoves, as the latter do not require to be cleaned as often. This would mean a considerable saving in labour actually expended in the blast-furnace plants for removing the dust which accumulates in a very short time in the flues of the hot blast stoves. It would even be possible by using clean gas to do away entirely with the spare hot blast stoves, thus saving considerably on the first cost of the installation. As the gas washing apparatus delivers the gas under a pressure of from 3 to 4 inches of water, the size of the conduits for conveying the gas could be decreased for new blast-furnace plants, which again would mean a reduction in the first cost.

That the clean blast-furnace gas is far more advantageous in its use than dirty gas is shown by an experience had at the blast-furnace plant at Seraing. After cleaning a boiler and putting it into commission again, it required with dirty gas 3 hours' time to get up the steam pressure, while by using clean gas this time could be reduced to 1½ hours. It is a well-known fact that clean gas burns far better than gas containing considerable quantities of very fine dust.

In Europe the centrifugal gas cleaning apparatus invented by Edward Theissen is used almost exclusively for gas cleaning plants. This apparatus requires for a given amount of gas less power, less water and less attendance, and is giving far better results than the so-called hydraulic fans which were used six years ago. In the blast-furnace plant of the John Cockerill Company, for instance, all the gas produced by two blast furnaces is subjected to a thorough washing in Theissen gas washers of the largest capacity, and the Cockerill Company intends in the near future to clean in this way all the gas produced by seven furnaces. After leaving the first installation of Theissen apparatus the gas is divided in two branches, one part going directly to the hot blast stoves and boilers, while the other branch leads to a second series of Theissen gas washers where the gas is subjected to a second washing and scrubbing process, thus making it perfectly clean and suitable for operating gas engines.

According to the experience as indicated by European practice for cleaning the gas generated by the blast furnaces, it may be assumed that all the gas for our 800-ton blast-furnace plant is to be cleansed in Theissen gas washers of large capacity, to such an extent as not to contain more than about 0.5 gram of dust per cubic meter. The part of the gas for operating gas engines will be subjected to further cleaning in Theissen gas washers, which will bring down the amount of dust contained in the gas to 0.03 gram per cubic meter (corresponding to 0.0131 grains per cubic foot) or even to a

less amount. Experience shows that engines using clean gas are able to run 6 months and more continuously day and night without the necessity of cleaning them internally.

In order to clean 10,000 cubic feet of gas per hour to such a degree of cleanliness as to be suitable for the hot blast stoves, the Theissen gas washers require about 1.25 horse-power (actual test shows 1.15 horse-power). The power necessary for cleaning the whole quantity of 4,350,000 cubic feet of gas per hour will therefore amount to 435 × 1.25 = 550 brake horse-power. As stated before, 30 per cent. of this clean gas goes to the stoves, leaving 70 per cent. to pass through the second series of Theissen gas washers. Gas cleaned for gas engine purposes in Theissen gas washers requires about 1.5 brake horse-power for each 10,000 cubic feet of gas per hour. Actual tests show only 1.3 brake horse-power.

The power required for the second series of gas washers will therefore amount to 0.7 × 435 × 1.5 = 460 brake horse-power, and the total power required for gas washing purposes will be 1010 brake horse-power. Gas dynamos will generate the necessary electric current for operating the electric motors of the gas washers.

With a combined efficiency of 85 per cent., the required capacity of the gas engine will be about 1200 brake horse-power, and at the rate of 100 cubic feet of gas per brake horse-power per hour, there will be required for gas cleaning purposes another 1200 × 100 = 120,000 cubic feet of gas per hour. Figuring back on the tonnage of pig iron, it will be seen that the power required for gas cleaning purposes amounts to about 1.5 horse-power per ton of pig iron produced in 24 hours. This figure coincides very nicely with the figure given by W. Oswald, of Coblenz, which is 1.6 horse-power per ton of pig iron produced per 24 hours.

GAS LOSSES

In the piping for the engines, in the gas engines themselves and in the gas cleaning plant, about 5 per cent. of the gas required might be lost by leakage, etc. The total loss would therefore amount to 0.05 × 960,000 = 48,000 cubic feet.

After deducting the quantities of gas necessary for the various purposes of the blast-furnace plant, there remains available for other purposes in round figures 2,000,000 cubic feet of gas per hour, as shown by the following summary:—

TABLE NO. 1.—COMPUTATION OF FURNACE GAS AVAILABLE FOR POWER

Summary

	Cubic Ft.	Cubic Ft.
Total amount gas produced per hour	......	4,350,000
Amount to be deducted:		
For hot-blast stoves	1,305,000	......
For gas blowing engines	720,000	......
For operating auxiliary machinery	120,000	......
For operating gas cleaning plants	120,000	......
For losses in piping, engines, etc.	48,000	......
Totals	2,313,000	2,313,000
Available for purposes outside blast-furnace requirements per hour		2,037,000
In round figures per hour		2,000,000

This quantity of gas at the rate of 100 cubic feet per brake horse-power per hour would provide for 20,000 brake horse-power. Per ton of pig iron produced per 24 hours there will therefore be available for sale or for other useful work 25 horse-power. As found previously, the total quantity of gas generated by two 400-ton furnaces represents over 50 brake horse-power per ton of pig iron produced per 24 hours. Generally speaking, 50 per cent. of the power represented in the gas produced by a blast-furnace plant is available for sale.

The blast furnaces are subject to certain unavoidable irregularities on account of which a "coefficient of safety" must be introduced in the calculation for determining the available power from a blast furnace of a given capacity. This coefficient is of course extremely variable and depends largely upon the pig iron market, which might require a banking of the furnaces, upon the operation of the furnaces, the quality and supply of ore, etc. It is very difficult to foretell how much of the total theoretical available horse-power from two 400-ton furnaces could actually be realized, especially when the electric power generated by using this gas in gas engines is to be sold to outside consumers to whom the delivery of a certain amount of power naturally must be guaranteed, perhaps under a heavy penalty. This irregularity in the operation of a blast furnace will have a very great influence on the production of gas, affecting the quantity as well as the quality. With two blast furnaces only, it would be perfectly safe to figure on the available horse-power from the gas of one furnace only, assuming this coefficient to be 0.5.

Following the above outlined order of ideas, a blast-furnace plant of only two 400-ton furnaces should be equipped in the beginning with a power station of only capacity corresponding to the available power from only one furnace, installing later on additional units, if the conditions and operations of the furnace plant would be such as safely to permit the generation of additional electrical power.

The following calculation has been made on the assumption that an electric power plant of about 10,000 brake horse-power be installed first. The size of unit best suited for this power plant would be an engine of about 1500 brake horse-power capacity. Seven gas engines of 1500 brake horse-power rated capacity would develop 10,500 brake horse-power. In order to meet emergencies, an eighth engine as a standby or spare unit should be installed, so that the power plant in the beginning would consist of eight units as above.

Generators of 800 KW. would develop, at the rated load of the gas engines of 1500 brake horse-power, about 1000 KW., or 800 KW. plus 25 per cent. overload. At maximum load of the gas engines of 1650 brake horse-power, the generators would carry 1120 KW. each, or 800 KW. plus 40 per cent. overload. It will be seen that 800-KW. generators would perfectly fulfill the requirements, as they easily stand an overload of 25 per cent. for 24 hours and an overload of 40 per cent. for short periods.

COST OF ELECTRIC POWER STATION OF 10,000 BRAKE HORSE-POWER CAPACITY

The complete equipment of the power plant would consist of the following:—

Eight double-acting tandem Wellman-Cockerill gas engines, 38 inches diameter by 54 inches stroke, at 85 revolutions per minute, with a rated load of 1750 indicated horse-power, or 1500 brake horse-power each, to be direct connected to alternating-current generators, 800 KW. three-phase, 25-cycle, 6600-volt, and including exciters, switchboard and wiring.

Gas cleaning plant for power station only.

Complete piping.

Air compressor outfit.

Buildings, foundations and traveling crane.

The cost of the installation of the power plant is given in detail in the following table:—

TABLE NO. 2.—COST OF INSTALLATION OF POWER PLANT

	Weight Pounds	Cost
Gas cleaning plant	250,000	$33,500
Building and foundation for same	......	6,500
Ring gas main	100,000	6,000
Building for eight gas dynamos	......	45,000
Foundation for engines	......	26,000
Traveling crane	120,000	8,500
Eight gas engines	4,000,000	424,000
Complete piping	470,000	24,000
Air-compressor outfit	40,000	5,000
Complete electrical equipment	670,000	162,500
Total weight of machinery	5,650,000	
Total cost of installation		$741,000

Cost of installation per brake horse-power (total capacity, 12,000 brake horse-power)	61.60
Cost of installation per kilowatt (total capacity, 8300 KW.)	89.50

VARIOUS ITEMS OF INSTALLATION COST

Gas Cleaning Plant.—The part of the gas washing plant chargeable to the power house, has to clean a maximum of 12,000 × 100 = 1,200,000 cubic feet of gas per hour, or 20,000 cubic feet per minute, provided that all eight gas engines are in operation under full load. This quantity of 20,000 cubic feet of gas per minute, which has previously been cleaned with the bulk of the gas of the furnaces, can be cleaned by a gas washing plant consisting of four Theissen gas washers No. 3, capable of cleaning an average of 6000 cubic feet of gas per minute each. A spare Theissen apparatus is not necessary, as in case of a shut-down of one washer for cleaning or repairs the three remaining washers will easily take care of the total quantity of gas. Each Theissen apparatus would be directly coupled to a 70 brake horse-power electric motor running at a speed of about 450 revolutions per minute.

Between the gas main and the Theissen apparatus there should be inserted a pressure regulator which automatically shuts off the entrance of gas to the cleaning plant in case of lack of gas, thus avoiding a vacuum in the main gas conduit and consequently preventing the entrance of air into the latter, which might produce dangerous explosive mixtures in the pipe line. The gas pressure regulator and the four Theissen gas washers could be arranged in such a way that by the simple manœuvering of a few valves the gas can be by-passed at the pressure regulator of each Theissen apparatus, thus permitting the cleaning or repairs of the latter without interfering in the least with the operation of the power plant. Each Theissen apparatus would deliver the clean gas into the water separator situated in front of the gas washer. These separators take out the water from the gas and deliver clean, cool, dry gas into a collecting pipe, which in turn is connected to the gas main situated around the engines. All piping for connections of the various items of the cleaning plant, as well as all water piping, is included in the price.

A light steel frame building with brick walls and solid roof is sufficient to shelter the Theissen gas washers, their motors and the water separators. This building would be about 100 feet long and 30 feet wide, and should be provided with a traveling crane of 5-ton capacity and 30-foot span. Surrounding the engines and the building there should be installed a ring gas main of about 4 feet diameter from which the engines take their supply of gas. This ring conduit avoids all possible interference between the gas streams leading to the various engines and secures a uniform supply of gas. No connection between this gas main and the gas cleaning plant has been considered in this estimate, as it depends upon the local conditions and arrangements.

Building for Gas Engines.—The building for the gas engines would be about 85 feet wide and 250 feet long. It should be of steel structure with brick walls and slate roof, with hard wood floor, and provided with runways for the electric traveling crane. Each 1500-H. P. gas engine requires a volume of concrete of about 10,000 cubic feet. The price as given in Table 2 includes foundations for eight engines and all the iron work, such as foundation bolt washers, girders, supports for piping, etc. An electric traveling crane of about 25 tons capacity and about 85-foot span, with main and auxiliary trolley, would be required.

Gas Engines, Compressors, etc.—The price as given for the gas engines would include all the necessary auxiliary apparatus, such as electrically-driven barring-over devices, pumps operated by the main shaft of each engine for circulation of water under pressure through pistons and piston rods, complete piping, etc. Modern double-acting tandem gas engines will perform 1 brake horse-power at full load on 9000 British thermal units, or 100 cubic feet of gas; at $\frac{3}{4}$ load on 10,000 British thermal units, or 112 cubic feet of gas; at $\frac{1}{2}$ load on 12,600 British thermal units, or 440 cubic feet of gas.

The air compressor outfit would consist of two electrically driven 2-stage air compressors having a capacity of 150 cubic feet of free air per minute each, compressing against 150 pounds to the square inch. A main compressor air reservoir with safety valve and gauges is included in the price. The capacity of each air-compressor outfit would be ample to permit the simultaneous starting of two engines.

The electrical equipment would comprise eight 800-KW. alternating-current generators, two exciter units, driven independently, the switchboard and the complete wiring between generators and switchboard.

OPERATING COST OF POWER PLANT

The operating cost of the power plant consists of:—

(a) Fixed charges, comprising the interest of the money invested in the plant, depreciation and maintenance of various items, insurance and taxes.

(b) The cost of water consumed for washing and cooling purposes.

(c) Cost of oil and grease.

(d) Expenditures for repairs on gas cleaning plant, engines, piping and electrical equipment.

(e) Expenditure for wages and salaries.

(f) Cost of fuel.

The computation of the operating cost of power plant has been made for three different assumptions:—

First.—The power plant running at full load capacity; output, 10,500 brake horse-power per hour = 91,980,000 brake horse-power hours per year, or 7250 kilowatts per hour = 63,510,000 kilowatt-hours per year.

Second.—Power plant running at three-quarters load; output, 8000 brake horse-power per hour = 70,080,000 brake horse-power hours per year, or 5500 kilowatts per hour = 48,180,000 kilowatt-hours per year.

Third.—Power plant running at half load capacity; output, 5000 brake horse-power per hour = 43,800,000 brake horse-power hours per year, or 3600 kilowatts per hour = 31,536,000 kilowatt-hours.

TABLE NO. 3.—FIXED CHARGES

	Cost	Interest. Per Cent	Deprecia-tion. Per Cent	Insur-ance. Per Cent	Total. Per Cent	Life of Plant. Years	Total per Annum
Gas cleaning plant	$33,500	5	10	1	16	8.31	$5,360
Building and foundations	6,500	5	4	1	10	16.62	650
Ring gas main	6,000	5	6	1	11	14.21	660
Buildings for eight gas dynamos	45,000	5	4	1	10	16.62	4,500
Foundations for engines	26,000	5	4	1	10	16.62	2,600
Traveling crane	8,500	5	5	1	11	14.21	930
Gas engines	424,000	6	8	1	14	9.95	59,360
Complete piping	24,000	5	5	1	11	14.21	2,640
Air compressor outfit	5,000	5	5	1	11	14.21	550
Complete electrical equipment	162,500	5	8	1	14	9.95	22,750
Totals	$741,000	5	..	..	13.5	....	$100,000

	Cents.
Fixed charges per kilowatt-hour at full load	0.1575
Fixed charges per kilowatt-hour at three-quarters load	0.2076
Fixed charges per kilowatt-hour at half load	0.3171

One year = 365 days, one day = 24 hours.

(a) Fixed Charges.—Table No. 3 gives the various items of fixed charges.

(b) Water.— Details under this

head, as under the remaining four heads of operating cost, are omitted here though given fully in the paper. At full load the total expenditure for water is $50 a day, or 0.02874 cent per kilowatt-hour. At three-quarter load it is 0.03514 cent, and at one-half load, 0.04236 cent.

(c) Oil and Grease.—For the entire power plant, including electrical equipment and auxiliary machinery, the yearly expenditure for oil and grease is figured at $15,645 at full load, or 0.02460 cent per kilowatt-hour; at three-quarter load, 0.02922 cent; at one-half load, 0.04219 cent.

(d) Repairs on Machinery.—Experience with large power plants in Europe indicates that repairs due to accident, apart from those included in depreciation and maintenance, do not exceed about 2½ per cent. per year of the purchase price of the gas engines and generators. For the gas cleaning plant 7 per cent may be assumed, 5 per cent. for the air compressor and 2 per cent. for piping and crane. At full load the total for repairs is about $18,000 a year, or 0.02834 cent. per kilowatt-hour; at three-quarter load, 0.03362 cent, and at one-half load, 0.04852 cent.

(e) Wages and Salaries.—In round figures, salaries and wages amount to $35,350 a year, or 0.05566 cent per kilowatt-hour at full load, 0.06953 cent at three-quarter load, and 0.10020 cent at one-half load.

(f) Fuel.—Following the late L. Ehrhardt - Schleifmuehle, who, he says, originated the idea of appraising blast-furnace gas, the author compares the value of blast-furnace gas with the actual cost of steam in proportion to the heat value. The reasoning is that the gas in the gas engine cylinders is utilized just as directly as the steam is in the cylinders of a steam engine. He arrives at 1 cent as the value of 1000 cubic feet of blast-furnace gas. A comparison is also made with natural gas and the value of gas required to drive the gas cleaning plant, together with maintenance and attendance, is reduced to an equivalency of coal, etc., which would be required in case steam were used. The fuel per kilowatt-hour at full load is thus figured at 0.1448 cent; at three-quarter load, 0.1629 cent; at one-half load, 0.1944 cent.

CONCLUSIONS AS TO COST

The author finds that the total of the six items enumerated above is 0.440 cent per kilowatt-hour for operating power plant, counting fuel equivalent to coal at $2.75, or 0.304 cent per brake horse-power hour. The paper then concludes as follows:—

It will be seen that a power plant of about 10,500 brake horse-power capacity, complete in every detail and installed in connection with a blast-furnace plant, would be capable when running at full load capacity of producing 1 brake horse-power per year at the low cost of $17.88, no value being placed on the blast-furnace gas. The enormous saving, as compared with the production of power in a steam engine plant, is still more striking when the cost generation of electric current is considered. According to the above tables, 1 kilowatt-hour at full load capacity of the plant could be produced at 2.5 mills, which is away below the best figure ever reached with a steam engine power plant. Even under worse conditions—that is, when the power plant is running on an average of only 50 per cent. of its total capacity—the cost of generation of 1 kilowatt-hour is but 5.50 mills. It is evident that an eventual increase in the capacity of the power plant would still tend to reduce the cost of the generation of power per unit, as certain expenditures for the power plant of 10,500 brake horsepower would remain unchanged for additional power units.

Computations of this character are sometimes considered as being "theoretical," as they naturally can only be made by making certain assumptions. That such figures have some practical value, inasmuch as they permit the clear understanding of the results of practical experience, accounting for the make-up of these figures, will be appreciated by studying actual figures obtained in the works of the John Cockerill Company.

ACTUAL EXPERIENCE OF THE JOHN COCKERILL COMPANY

The John Cockerill Company has in operation at present seven blast furnaces of about 1200 tons daily capacity, and in addition large steel plants, rolling mill plants, coal and ore mines, coke ovens, boiler shops, machine shops, bridge works, gunnery works, steam turbine works, locomotive works, etc. The Cockerill Company employs about 15,000 workmen, and its plant is considered to be the largest of its kind in Belgium and west of Germany.

In 1900 the Cockerill Company had 86 electric motors in use, while in 1905 the number of motors amounted to 333. The lighting outfit consisted in 1900 of 450 arc and 4500 incandescent lamps, whereas in 1905 the corresponding figures were 660 arc and 5600 incandescent lamps. In order to produce the power for the electric service, 1000 KW. in steam engines were installed in 1900. In 1901 the first gas engines operating direct-connected generators of 900 KW. total capacity were installed; in 1903, 900 KW. in gas engines were added and the capacity of the steam engine plant was decreased 200 KW., so that up to 1905 only 800 KW. in steam engines were in operation; in 1904 more gas engines were added, bringing the total capacity of the power plant up to 3700 KW. Inside of five years the capacity of the power plant has been increased 370 per cent.

A most interesting feature is the cost of operation of the power plant. In 1900 the total operating cost for 1000 KW. in steam engines amounted to 157,462.88 francs; in 1905, for the total capacity of the power plant of 3700 KW., the cost of operation amounted to 206,327.91 francs. The increase in the operating cost, therefore, amounted to 31 per cent. only, whereas the capacity of the power plant had been increased 370 per cent. Although even in the case that the power plant would have been enlarged by additional steam units, the operating cost would have been reduced in proportion, it is clearly evident that the greatest share of the reduction in the cost of operation is due to the installation of gas engines.

The output of kilowatt hours produced per year increased from 1,789,-281 in 1900 to 9,999,216 in 1905. The cost per kilowatt hour fell from 0.088 franc in 1900 to 0.0206 franc in 1905, so that the cost of 1 kilowatt hour in 1905 was but 25 per cent. of the corresponding cost in 1900.

There is no doubt that the operating cost of the power plant per kilowatt hour would have been decreased in the interval of five years, even in the case of an addition of steam units, as the power factor increased during this time; but the reduction in the cost of power per unit is almost exclusively due to the installation of gas engines. When, in 1901, 900 KW. in gas engines were added to the capacity of the power plant, the total cost of operation dropped, and more so in 1902, when the minimum of operating cost of power plant was reached. In 1903, when 900 KW. in gas engines were again added, the cost of operation advanced, but the total operating cost in the year 1903-1904 did not exceed the operating cost in 1900-1901, although the capacity of the power plant had been increased 280 per cent. In 1901, when only 900

KW. in gas engines existed, 753 francs were tied up per kilowatt. In 1905, when the total capacity amounted to 2900 KW. in gas engines, the money invested per kilowatt was only 578 francs. Although these results could not be used for a direct comparison with blast-furnace plants in this country, on account of the considerable difference in the general conditions of operation, cost of labour, etc., so that it would not be appropriate to transpose the operating cost per kilowatt hour into American money (0.0206 franc would correspond to 0.415 cent), the figures prove conclusively what benefit could be derived from the installation of gas engines for the various power purposes in a modern blast-furnace plant.

According to the "Bulletin" of the New York Edison Company, the motor installations now supplied by that company aggregate 106,126 H. P. This means probably that there are more than 40,000—perhaps 50,000—individual motors on Manhattan Island. They vary in size from $\frac{1}{8}$ H. P., or even 1-16 H. P., to single motors of several hundred horse-power. The service capacity of some single buildings reaches as high as 3000 and 4000 H. P.

An Engine Test in the Power House of the New York Subway

An interesting official 15-hour test of one of the nine twin vertical-horizontal Reynolds-Corliss engines, with cylinders 42-inch and 36-inch by 60-inch, which have been in operation at the Fifty-ninth street station of the Interborough Rapid Transit Co., in New York City, since 1902, was concluded December 15. The tests were conducted by the Interborough Rapid Transit Co. and representatives of the Allis-Chalmers Co., of Milwaukee, Wis., as a final determination of the fulfillment of the builder's guarantee and for-

THE FIFTY-NINTH STREET STATION OF THE INTERBOROUGH RAPID TRANSIT COMPANY, NEW YORK, SHOWING REYNOLDS-CORLISS ENGINES BUILT BY THE ALLIS-CHALMERS COMPANY, MILWAUKEE, WIS.

mally provided for in the original contracts.

How well the tests of engine No. 8, which was selected as representing all the engines installed, fulfilled the claims made for it, may be readily ascertained from the following data giving a synopsis of the completed tests. As per agreement, on account of the impossibility of keeping a constant load, the power was determined by the readings of tested integrating wattmeters. These readings were reduced to indicated horse-power by running the generator as a synchronous motor, adding the electrical input to the switchboard readings when developing power, to obtain the power exerted by the engine.

The result of the test so made, under conditions approximating the contract requirements of 7500 H. P., 75 revolutions per minute, 175 pounds steam pressure and 26-inch vacuum, was a consumption of 11.96 pounds of dry saturated steam per indicated horse-power-hour, or well within the Allis-Chalmers Company's guarantee of 12.25 pounds. The steam consumption per kilowatt-hour at the switchboard was 17.34 pounds.

Duration	15 hours
Load	5079.2 KW.
Friction and generator losses,	417.3 KW. = 559.41 H. P.
Total load	5496.5 KW.
I. H. P.	7365.3 H. P.
R. P. M.	75.02
Steam pressure	175.18 lbs.
R. H. receiver	19.1 lbs.
L. H. receiver	19.27 lbs.
Vacuum (actual)	26.02 lbs.
Temp. injection water	42.36 degs.
Temp. R. H. discharge	74.05 degs.
Temp. L. H. discharge	77.38 degs.
Barometer	30.50 lbs.
Water per hour	89 906 lbs.
Drips per hour	512 lbs.
Leakage per hour (boiler)	1.470 lbs.
Boiler level correction	60 lbs.
Net water per hour	87.864 lbs.
Quality of steam	100.28 per cent.
Dry steam per hour	88.110 lbs.
Dry steam per KW.-hour	17.34 lbs.
Dry steam per I. H. P.	11.96 lbs.

The final results allow for boiler leakage, this being determined by a separate test of 24 hours duration. The steam was very slightly superheated during the test, as it was easier to make allowance for than wet steam, and a correction was made to reduce the superheated steam to equivalent dry saturated steam.

The vacuum was carried at 26.02 inches, or as near the contract requirement as possible, but the barometer stood at 30.50 inches. The vacuum was, therefore, equivalent to only 25.52 inches referred to 30-inch barometer; no correction was made, however, as none was provided for in the contract. Other tests at varying vacua show that if the vacuum had been carried enough higher to correspond to 26 inches vacuum when referred to 30 inches barometer, the steam consumption would have been about 0.09 pound better, or 11.87 pounds per indicated horse-power-hour instead of the official figure of 11.96 pounds.

The tests were under the supervision of Frank N. Waterman, who acted as referee. The following represented their several companies:—

Interborough Rapid Transit Co.—H. G. Stott, superintendent motive power; J. Van Vleck, mechanical engineer; H. W. Butler, principal assistant engineer; Thomas Allsop, mechanical engineer. Fifty-ninth street power station; C. W. Ricker, electrical superintendent; G. F. Chellis, instrument man; W. L. Seabrooke and W. S. Finlay, assistant engineers.

Allis-Chalmers Co.—A. M. Mattice, chief engineer; Samuel Moore, district superintendent of erection; T. T. Hubbard, engineer of test; J. W. Lord, sales representative; C. A. Hoppen and C. J. Larsen, construction department; A. F. Rolf and F. Buch, electrical representatives.

Lower Telephone Rates in New York City

FOUR hundred telephone men of New York and vicinity had a dinner on January 19, and were addressed by a number of officers of the Telephone Society. In the speech of U. N. Bethell, general manager of the New York Telephone Co., interesting information in regard to the rates, service and personnel of that company was presented.

Mr. Bethell announced that on March 1, after a service of thirteen years in the position, he will retire from the office of general manager of the company. He will continue in the telephone business as first vice-president of the New York Telephone Company, and also as president of the New York & New Jersey Telephone Co. and the several other companies which operate in the territory between the St. Lawrence and the Potomac. During the thirteen years he has been the general manager, Mr. Bethell has seen the New York Co. increase in Manhattan and the Bronx from 9704 telephones to over 175,000.

After referring to the many changes that have taken place, Mr. Bethell took up the question of the company's policy with reference to rates. He showed that that policy had been one of continuous modification and reduction, the most notable decrease going into effect in the spring of 1905. He then reviewed the experience in Baltimore, Washington, Philadelphia, Newark, and other places where a local 5-cent pay station rate had been introduced, showing that in each case the reduction from 10 cents to 5 had resulted in a very great increase of business. The company has decided, he said, to reduce the local pay station rate in Manhattan and Brooklyn, respectively, from 10 cents to 5, but owing to the great increase in plant required to handle the traffic that would naturally follow such a change, it is not possible to make the change at once. He was able to say, however, that the 5-cent rate had been authorized by the board of directors, and that it will go into effect certainly by July 1,—probably by June 1. There may be some exceptions to a uniform 5-cent rate, inasmuch as in hotels and some other places where the proprietors furnish special facilities and attendants, a charge of 10 cents will be allowed at the discretion of the proprietors. The 5-cent local rate will be effective in Brooklyn at the same time as in New York.

The territory in which the New York and its allied companies operate stretches in crescent shape from the Potomac to the St. Lawrence, said Mr. Bethell, and they have altogether in service at the present time nearly 600,000 telephones, exceeding in number the total of Great Britain, France and Belgium combined, and equaling, if not exceeding, the number in the whole German Empire. The increase in this territory last year was 150,750, or 35 per cent.

In order to bring about further improvement of the service and more perfect harmony in the policy of the companies operating in New York and vicinity, it was announced that hereafter there will be but one operating department for the New York and the New York & New Jersey Companies. J. C. Reilly, who has been general manager of the New York & New Jersey Company, becomes vice-president of that company; J. J. Carty, chief engineer of the New York company, becomes chief engineer of both companies; H. F. Thurber, now superintendent of the New York company, will become general manager of both companies; Theodore Spencer becomes vice-president of the Bell, of Philadelphia; F. H. Bethell, vice-president of the Chesapeake & Potomac; H. F. Stevens, vice-president of the Central New York, and H. E. Hawley, vice-president of the Hudson River Company.

A trackless trolley line is being constructed from Melrose, Mass., to connect with the line of the Boston Elevated Railway Co.

Lightning Conductors

By H. W. WHITEHOUSE, M. I. E. E.

From a Paper Read Before the Birmingham and District Electric Club, England

FULLER states in his "Church History" "that scarcely a great Abbey or Cathedral in England exists which once, at least, was not burned with lightning from Heaven," and then proceeds to enumerate a great many so damaged or destroyed. If to this list we add the number of churches which have sufferred from this cause, the resulting total is certainly startling.

One writer states that during a single storm in Brussels twelve churches were struck, three of them being practically destroyed. Now it is estimated that 13,000 churches are protected by lightning conductors, and if one is struck and damaged, it is regarded as something unusual.

If we turn to the records of the British Navy the experience is equally instructive. Sir W. Snow Harris stated that the annual expenditure on vessels in the British Navy due to the destructive action of lightning averaged from £600 to £10,000. In 200 cases of vessels so struck, 300 men were either killed or disabled, and over 100 masts—representing a money value of £100,000—were entirely ruined.

Between the years 1810-1815, no less than 31 sail of the line and 35 frigates and smaller vessels were completely disabled. Now, since the introduction of lightning conductors, damage by lightning has practically vanished from the record of the Navy. Sir Wm. H. Preece, before the British Institution of Electrical Engineers in 1889, said, "There are ships in Her Majesty's Navy that have been for 50 years fitted up according to the principle of Sir W. Snow Harris. Since 1872 there has not been an accident recorded in the Admiralty, although there are always 500 or 600 ships under commission, sailing in every sea, subject to every climate at all times, and in all seasons."

Equally interesting and conclusive evidence as to the efficacy of a properly constructed lightning conductor is afforded by the experience of the British War Department and the Postal Telegraphs. Sir Wm. Preece, the then chief engineer to the Postal Telegraphs, at the meeting previously alluded to of the Institution of Electrical Engineers said, "In 1872, 19 per cent. of our instruments were damaged by lightning; now, in the year ending March 31, 1889, the number damaged has only been 1.3 per cent." This remarkable result has been brought about by the improved form of lightning protector attached to the various circuits, and also by the fact that the "earth wire" (an ordinary No. 4 galvanized iron wire which is run down each pole) acts as an efficient lightning conductor.

With such remarkable and unanimous testimony it might reasonably be thought that we had in a lightning conductor a perfect piece of apparatus, and yet the writer has no hesitation in saying that so far as buildings are concerned, especially large ones, the complete security supposed to be afforded by an ordinary conductor is a myth; and that the immunity of ships is due to a very great extent to the fact that nearly all modern vessels are mostly if not entirely of iron, thus forming, as will be shown later, an ideal lightning protector.

A recent writer remarks, "Conductors sometimes fail when they appear to have been applied in accordance with the rules supposed to govern the subject. On the other hand, cases occur in which conductors that would be condemned as inefficient under those same rules, serve perfectly, when struck by lightning. This anomalous state of affairs shows that there is some important factor that is very frequently overlooked, and which must be the crux of the question."

This is not a desirable state of affairs, and considering the enormous loss of life and property (estimated at £100,000 per annum in Great Britain alone) occuring every year, in Great Britain and other countries, the subject deserves serious attention.

During the year 1899 there were reported in the British press the following list of casualties:—

People killed	25
People injured	114
Churches and chapels struck	17
Hotels, inns and the like, struck	12
Castles and country mansions struck	5
Houses, cottages, and buildings	237

During the same year, in America, there were 562 killed, and over 800 injured.

It is not the writer's intention to deal with the debatable subject of atmospheric electricity, being content to wait until some tangible theory has taken root. At one time, electricity was stated to be a fluid; subsequently, a strain in the ether; now, chunks of some wonderful unknown thing flying about, and called "electrons."

Whatever may be the cause of the difference of potential between the clouds and the earth, there is no question as to the result being similar to that of a Leyden jar, on a discharge taking place, this discharge taking different forms known generally as zig-zag or forked, sheet, and globular lightning.

The duration of a lightning flash varies from $\frac{1}{100\,000}$ to $\frac{1}{1\,000\,000}$ of a second, and considering that the human eye requires about $\frac{1}{10}$ of a second to realize the brightness of an illuminant, it follows that the actual brightness of a flash must be thousands of times greater than it appears to the observer. The maximum length of flash observed is about 10 miles.

The thunder is simply the reverberation of the sound, caused by the fracture of the dielectric or air, and this sound traveling about 1110 feet per second, or 1 mile in 4 2-3 seconds, enables one to estimate the distance of the discharge. The greatest distance at which thunder has been heard is about 15 miles.

During the past seventeen years attention has been directed to the subject of lightning conductors by papers read by Sir Oliver Lodge before the Society of Arts, the British Association, and the Institution of Electrical Engineers, in which he attacked the orthodox theory of lightning conductors.

These papers were illustrated by some beautiful experiments which will be described later. Without endorsing Sir Oliver Lodge's condemnation of the present form of conductor, and the theory of its action, there can be no doubt that, viewed in the light of these experiments and recent advances in electrical science,

the older ideas will have to be extremely modified; not because they were radically wrong, but because, with the fuller knowledge we now have of the subject, we see that the phenomena of atmospheric electricity is of a more complex nature than was previously supposed, and that conditions, not contemplated by electricians a few years ago, may, and in fact do, exist.

In order that it may be clearly understood wherein these modern views differ from those previously held, it will be necessary to briefly trace the history of the invention of lightning conductors, and to illustrate the theories hitherto generally accepted.

We are told by a recent reviewer that "the first lightning conductor was erected by Benjamin Franklin upon his own house in Philadelphia in the year 1752, he being led to the investigations resulting in its construction by the fact that in 1746 he had been present at a lecture on electricity, delivered in Boston by Dr. Spence.

"The idea had already suggested itself to investigators that the luminous gleam which was elicited from glass tubes when they were rubbed in dark cellars, in performance of the frequently repeated and fashionable experiment of the day, might possibly be of a kindred nature to the lightning of the thunderstorm. In 1709, Francis Hawskbee remarked that the luminous flash and cracking sounds produced by rubbing amber were similar to lightning and thunder. In 1720, Stephen Gray, the pensioner of the Charterhouse, so celebrated for his electrical investigations, boldly and uncompromisingly affirmed that 'if great things might be compared with small,' the light and sound called forth when glass rods were rubbed were of the same nature as lightning and thunder.

"Franklin, from the time when the electrical experiments came under his notice, enthusiastically adopted this view. In a letter written to a friend in 1749 he very clearly expresses his reasons for this belief. In this communication he insisted upon the facts that the electric spark gives light like lightning; that the luminous discharge follows a similar crooked track; that this discharge is swift in its motion, is conducted by metals, is accompanied by an explosion when it escapes, rends bodies that it passes through, destroys animal life, melts metals, sets fire to inflammable substances, and causes a smell of sulphur (ozone); all of which attributes seemed to him to point to the identity of the phenomena. He also observed that the electric discharge was attracted by points, and stated that he was bent upon ascertaining whether lightning had not the same tendency.

"In the autumn of the following year he wrote to Mr. Collinson to say that he had satisfied himself in this particular, that he was entirely convinced of the identity of the so-called electricity with lightning, that he believed the damage done by lightning descending from the clouds to the earth might be altogether prevented by placing iron rods with sharp points upon the summits of buildings, that he intended to test experimentally the soundness of his belief in that matter, and that he hoped other persons would assist him in his labours by following his example. This was virtually the definite forecast of the conductor which Franklin attached to his house in 1752.

"The editor of 'The Gentleman's Magazine,' perceiving the practical importance of the subject, offered to print an account of Franklin's views in the form of a pamphlet. This offer was accepted, and in the month of May, 1751, a pamphlet was published in London, entitled 'New Experiments and Observations on Electricity made in Philadelphia, in America, by Benjamin Franklin.'

"The pamphlet was not very warmly received in England, but it was enthusiastically welcomed and appreciated in France. The attention of scientific men in Paris was quickly drawn to the method of defense proposed by Franklin, and M. Dalibard, a man of some wealth, undertook to erect the apparatus at his country residence at Marly-la-Ville, about 18 miles from Paris. The situation of the house was considered to be eminently favourable for the purpose, as the buildings stood 400 feet above the sea. A lofty wooden scaffold, supporting an iron rod an inch in diameter and 80 feet long, was erected in the garden. The rod was finished at the top by a sharp point of bronzed steel, and it terminated at the bottom, 5 feet above the ground, in a smaller horizontal rod which ran to a table in a kind of sentry-box, furnished with electrical apparatus.

"On May 10, when M. Dalibard was himself absent in Paris, the apparatus having been left temporarily in the charge of an old dragoon named Coiffier, a violent storm drifted over the place, and the old dragoon, who was duly instructed for the emergency, went into the sentry-box and presented a metal key, partly covered with silk, to the termination of the rod, and saw a stream of fire burst forth between the rod and the key. The old man sent for the Prior of Marly, who dwelt close by, to witness and confirm his observation, and then started on horseback to Paris to carry to his master the news of what had occurred. Three days afterwards, that is, on May 13, 1752, M. Dalibard communicated his own account of the incident to a meeting of the Academie des Sciences, and announced that Franklin's views of the identity of the fire of the storm-cloud with that of the electrical spark had been thus definitely established.

"Before the success of M. Dalibard's experiment could be reported in America, however, Franklin had secured his own proof of the identity by the memorable experiment with the kite, so well known to the scientific world. He was anxiously waiting for the erection of the first steeple in Philadelphia for the opportunity which this would afford him for the support of a lofty iron rod, when the happy idea occurred to him to try, in the meantime, upon some suitable occasion, whether he could not contrive to hold up a lightning conductor towards a stormcloud by means of a kite. On the evening of July 4, that is, fifty-two days after the experiment of M. Dalibard, his kite was raised during a thunderstorm, and, with the help of his son, he drew electric sparks from the rain-saturated string, as the two stood in the shelter of an old cow-shed in the outskirts of Philadelphia. He held the kite by a silken cord that was attached to a key at the bottom of the string, and with this arrangement he charged and discharged an ordinary Leyden jar several times in succession.

"Franklin at first not unnaturally conceived that he had actually drawn the lightning down from the stormcloud. He was, however, no doubt mistaken in this. The stormcloud had inductively excited the neighbouring surface of the earth, and what Franklin saw was the electric stream escaping out through the wet string towards the stormcloud to relieve the tension set up by this induction. It was in the summer of the same year, after the performance of this world-renowned experiment with the kite, that Franklin attached to his house a lightning conductor, which was composed of an iron rod, having a sharp steel point projecting 7 or 8 feet above the roof, and with its lower end plunged about 5 feet into the ground.

"As a matter of course, the new doctrine of Franklin and his allies was not received without considerable opposition. A sharp shock of an earthquake having been experienced

in Massachusetts, in 1755, this was forthwith attributed to the evil influences of Franklin's lightning rods. A Boston clergyman preached against them in 1770 as 'impious contrivances to prevent the execution of the wrath of Heaven.' Even as late as 1826, an engineer in the employment of the British Government recommended that all lightning rods should be removed from public buildings as dangerous expedients, and, in 1838, the Governor-General and Council of the East India Company ordered that all lightning rods should be removed from public buildings, arsenals, and powder magazines throughout India, and only became reconciled to their restoration after a large magazine and corning house, not furnished with a conductor, had been blown up during a storm.

"The second conductor which Franklin constructed was placed upon the house of Mr. West, a wealthy merchant of Philadelphia. A few months after this had been erected a storm burst over the town, and a flash of lightning was seen to strike the point of the conductor, and to spread itself out as a sheet of flame at its base. It was afterwards found that about two inches and a half of the brass point had been dissipated into the air, and that immediately beneath, the metal was melted into the form of an irregular blunt cap. The house, nevertheless, was quite uninjured. The sheet of flame seen at the base of the conductor Franklin correctly ascribed to the ground having been very dry, and to there not having been a sufficiently capacious earth contact under those circumstances. He nevertheless shrewdly, and quite justifiably, assumed that in this case nature had itself pronounced an unmistakable verdict in favour of his invention."

Equally conclusive was the experience with H. M. S. "Conway," a small frigate of 28 guns, moored at Port Louis, Isle of France, when at 11 A. M., March 9, 1846, the vessel (which was provided with proper conductors) was struck by lightning. At the time of the disaster the vessel was under refit, with top gallant mast down on deck, so in order to support a pennon a small spar without a conductor was substituted for the top gallant mast. This spar was shivered to splinters by the discharge, but the remainder of the mast, which was provided with a conductor, was uninjured.

From time to time during the present century, reports have been issued by the Academy of Sciences of France, and more recently by the lightning rod committee of the Meteorological Society of London, in which suggestions have been offered as to the best methods of protecting buildings from damage by lightning. It is impossible here to refer to more than three of these suggestions.

Briefly, these are:—The conductor to be a continuous rod of copper or iron, of ample cross-section (preferably of copper on account of its lower resistance than iron), terminating in a spike, placed a few feet above the highest portion of the building and continued down to the earth, and there fastened to an earth-plate buried in damp ground, or, if possible, in a well; the conductor to be of one piece of metal, or, if made in sections, all joints to be well riveted and soldered.

We thus see that a conductor consists essentially of three parts:—*A*, the spike or collection of points; *B*, the rod; and *C*, the earth connection. The earth connection is of vital importance, and the majority of conductors as at present erected are decidedly faulty in this respect. The writer has tested a large number of conductors, and has found that in fully 90 per cent. the earth connection has not been satisfactory.

The following experiments, coupled with a few quotations from recently published accounts of damage caused by lightning, will serve to emphasize the importance of these three rules:—

Points.—Although the old two-fluid theory of electricity is obsolete, it will serve our purpose if we employ some of the terms formerly used in connection with that theory, and, therefore, more or less familiar. When a body is electrified, say, positively, then an equal amount of negative electricity is produced on surrounding objects, and the tendency is for these opposite charges or states of electrification to combine together and neutralize each other. Thus supposing a cloud to be positive, then the ground and buildings will be charged negatively, a strain being set up in the air lying between the cloud and the earth, buildings, etc. Since the inductive action is greater the thinner this layer of air, it follows that the tops of lofty buildings being nearer the cloud, the negative electricity will be accumulated on such buildings, and, supposing the charge of the cloud to become so great that the resistance of the air is overcome, then a discharge will occur; thus buildings, owing to their near proximity to the cloud, will be more liable to be struck than the surface of the ground.

In Fig. 1, an artificial cloud, consisting of a metal plate, is hung about 2 feet above a table, balanced on a radial arm free to turn on a vertical rod; this rod is in connection with the inner coating of a Leyden jar, the outer coating of which, resting on the surface of the table, represents the surface of the earth. At the far end of the room is an electroscope. If a small positive charge is given to the electroscope the two leaves will diverge; by bringing a positively-charged body near the electroscope the leaves will still further diverge; while, with a negatively-charged body, the divergent leaves will collapse. We are thus provided with a means of not only detecting a state of electrification, but also of ascertaining whether the electrification is positive or negative.

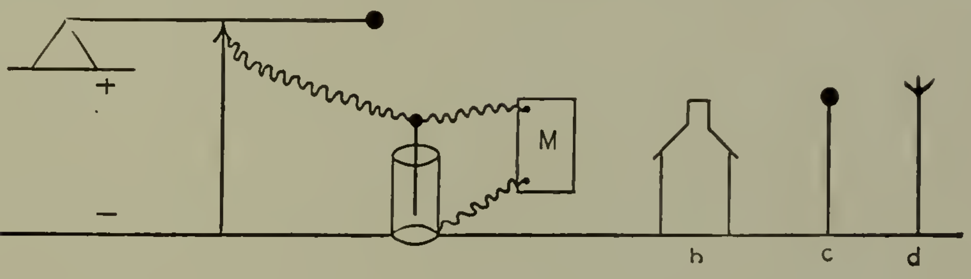


FIG. 1.

On charging the cloud positively by a Whimshurst machine *M*, and touching it with a small carrier, and then bringing the carrier into contact with the electroscope, the latter can be charged and the leaves caused to diverge with positive electricity. If the surface of the table (i. e., the earth) be touched with the carrier immediately underneath the model cloud, and the carrier be then brought to the electroscope, the leaves collapse, showing that the charged cloud has induced an opposite or negative charge on the table.

By placing a small model of the gable end of a house *b* under the cloud and repeating the experiment, the negative charge on the top of the chimney is greater than can be obtained from the surface of the table, this being due to the circumstance that the top of the chimney is nearer to the inducing cloud.

A metal rod *c* is then placed up the side of the house, the lower end resting on the table, and also connected to the outside of the jar, thus representing good "earth," the top of

the rod having a brass ball fixed to it. On giving a good charge to the cloud it begins to move vertically up and down, as though it were attracted by the building, until the distance

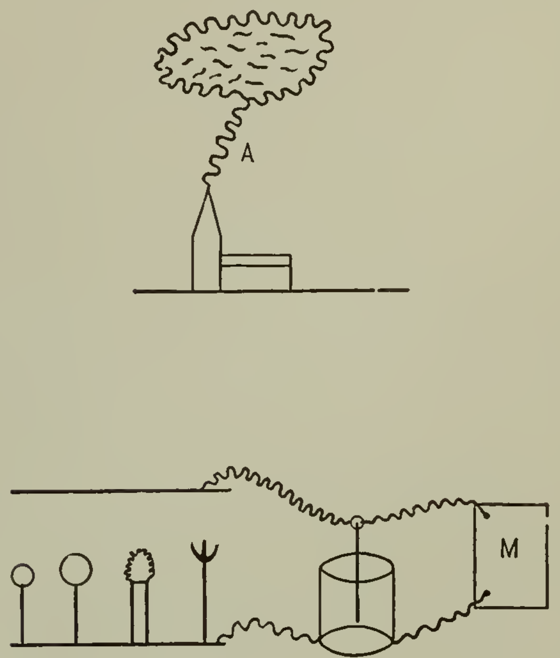


FIG. 2.

is so decreased that a violent discharge takes place between the cloud and the brass ball; immediately afterwards, the charge being completely neutralized, the cloud swings upwards and moves away.

The conductor in this case has saved the house, but it waited until it was actually struck, and, although this is one, and a most important, function of a conductor, it is not the only one, as the next experiment will show.

Keeping the apparatus as before, but substituting a spike *d* in lieu of the brass ball at the top of the conductor, we shall find on again charging the cloud that it has no tendency to approach the spike; on the other hand it strives to get away. In a dark room it will be seen that each point of the spike emits a pale brush-shaped light; in fact the conductor is silently discharging its negative electricity into the cloud, thus tending to neutralize the positive charge and so relieve the strain.

These faint lights are often seen on the ends of the masts and spars of vessels, and are known to sailors by the name of St. Elmo's fires. A very fine display was seen on the vane of St. Philip's Church, Birmingham, during a heavy thunderstorm one Sunday evening some few years ago.

We thus see that the work of a conductor is not only to be struck and then convey the discharge harmlessly to earth, but to prevent such discharge taking place by constantly allowing the induced charge to dissipate itself into the cloud. These facts have been known for years, but recent experiments have shown that the lightning flash may be due either to what Sir Oliver Lodge calls "steady strain" or "impulsive rush," the liability of different objects to be struck depending upon the conditions immediately preceding the discharge. Consider the two following cases:—

Steady Strain.—This occurs when the strain in the dielectric near the earth has been of gradual growth, in which case the path of discharge will be prepared inductively beforehand, as at *A*, Fig. 2. Placing between our artificial cloud and earth, a large knob or dome, a small knob, a point, and a flame, as shown in Fig. 2, they will be struck in the following order:—Knob, dome, flame, point. This is called the *A* spark.

Impulsive Rush.—This occurs when the strain rises so suddenly, due to one cloud discharging into another, as at *A*, Fig. 3, that there is no time for any pre-arranged path between the cloud so struck and the objects in its immediate neighbourhood. Placing the same four objects between the plates as in the "steady strain," the flame will be struck first and the others equally. This is called the *B* spark.

The advocacy of points instead of knobs by Franklin gave rise to a great amount of discussion at the time, as, owing to the fact that he was the representative of America in England, points were regarded as typical of Republicanism, and George III. decided to have knobs put on the top of rods at Kew Palace.

We are told that Sir J. Pringle, president of the Royal Society, when consulted by the King, said "the laws of nature were not changeable at the Royal favour," and a certain wag wrote as follows:—

"While you, Great George, for safety
  hunt,
And sharpe conductors change for
  blunt,
 The empire's out of joint:
Franklin, a wiser course pursues,
And all your thunder fearless views,
 By keeping to the point."

Conductors.—As to the importance of the conductor being continuous throughout its length, it is so manifest that it will not be further alluded to, but as to the necessity of its being of ample cross-section, the writer may instance the case of Chichester Cathedral. A few years ago, during a thunderstorm in the night, the conductor attached to the spire of this cathedral was struck, scattering the greater portion of the conductor into fragments. This conductor was of a most objectionable type, namely, twelve copper wires placed side by side and woven together into a kind of ribbon by zinc threads, its weight being only about ten ounces per yard. The conductor descended the spire, crossed the lead flashing of the roof, down the main wall, and ended in a well in the graveyard. After the discharge, it was found that the upper portion of the conductor was totally destroyed, being scattered about in thousands of pieces corresponding in size to that of the mesh into which it had been woven; but that portion of the conductor below where it touched the flashing of the roof was intact, the metal of the roof and downspouts offering a better path to earth than the poor conductor.

What was considered a remarkable incident occurred in connection with the destruction of this conductor. Opposite the cathedral stands the Dolphin Hotel. About an hour after the storm a smell of burning wood was perceived by the inmates. On investigation this was found to proceed from a beam of wood in one of the cellars, where a gas pipe had been melted for several inches and the gas ignited, thus setting fire to the

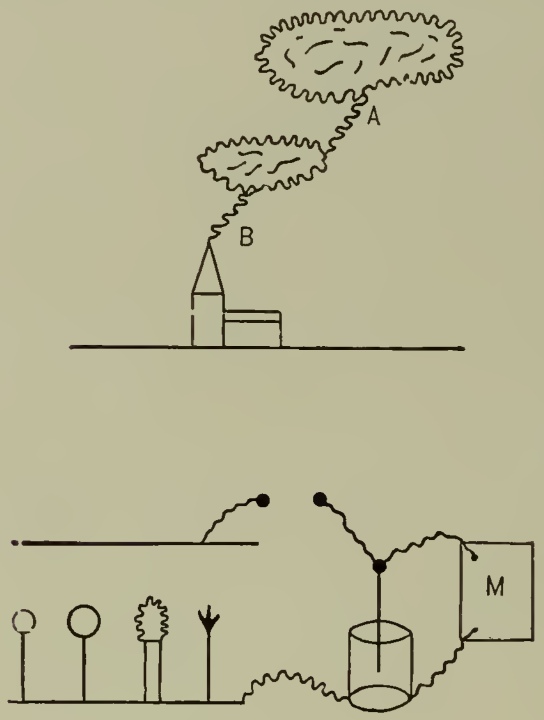


FIG. 3.

wooden beam. No traces of any disruptive discharge were visible in the cellar, but as an iron water pipe passed across, and close to, the gas pipe, it was thought the lightning had entered by this water pipe, and, darting across to the gas pipe, had fused it. This was a very plausible but weak explanation, and we shall see later on what light the new theory throws on this singular occurrence.

Earth.—It is here that we find the weak point in the construction of the

average conductor, fully bearing out the old adage, "Out of sight, out of mind."

In the year 1865, the tower of All Saints' Church, Nottingham, was struck by lightning. The tower, 150 feet high, had a small rope of copper wire, intended to act as a lightning conductor, running from one of its corner pinnacles to the ground, where it terminated by being coiled round a stone buried a few inches in dry soil. On the inside, and near the base of the tower—the walls of which were 4 feet thick—was one of the iron gas brackets used for the lighting of the church. The lightning traversed the conductor to this point, then passed through the solid masonry to the gas pipe, fusing the latter and setting fire to the church. In a precisely similar case the end of the conductor was led into a gravestone.

Ignorance of what constitutes a good earth connection was the cause of both accidents. Even a few years ago the writer saw the end of a conductor attached to a new church, near Birmingham, laid in a shallow hole and carefully covered over with lime—supposedly to keep it dry.

In the early published rules it was considered that a conductor would protect a circular area having a radius of twice the height of the conductor; but the fallacy of this was perceived, and presently abandoned, and instead of considering one conductor adequate, the erection of a rod on each prominent feature of the building was recommended, all of the rods not only being well earthed, but also connected together and to all the metal on the roofs of the building. Subsequently, owing to the extensive use of iron in the interior of buildings, it was suggested that the whole of this ironwork should be also connected to the conductors, and, therefore, to the earth plate, the idea underlying this suggestion being to approximate the building to a metallic cage, it being well known that no electrical charge can affect a body inside a metal vessel or cage.

On placing the electroscope underneath the cloud, and giving a feeble charge to the latter, the leaves of the electroscope immediately diverge; but if a wire gauze net be placed over the electroscope, it matters not how strongly the cloud is charged, the leaves not being affected. Thus we are led to expect that the nearer we can construct our buildings to the conditions of a metal cage the greater is the protection.

That even these elaborate precautions are not always sufficient, is shown in the case of what was long considered the most perfectly protected building in the world. The Hotel de Ville, at Brussels, is surmounted by a tower 297 feet high, with a gilt statue of St. Michael, at the top, holding a sword in his hand; from this sword, and from a ring of forty-eight points radiating to a distance of 8 feet from the foot of the statue, six rods lead down to the earth, on their way being joined by other rods from the various pinnacles, turrets, gables, etc., the total number of points projecting from the building being 426. For earth connection, the vertical rods were taken down to an iron box, and the box then filled in with molten zinc. From the box, twenty-four iron rods issued, eight being carried to an iron cylinder buried in a well, eight being connected with the water mains, and eight with the gas mains, thus providing 330,000 yards of earth connection. In 1884, a writer stated, "It may safely be affirmed that it is quite as difficult for the lightning to get mischievously at the building as it is for a discharge to get inside an iron cage." And yet, recently, the Hotel de Ville was seriously damaged by lightning.

Having thus briefly sketched the theory and practice which has hitherto been more or less successfully followed, it remains to describe two experiments illustrative of the new theory put forth by Sir Oliver Lodge.

Chiefly the difference between the old and new theories is this:—Is a lightning discharge direct or alternating? If direct, i. e., in one direction, or an ordinary single stroke, then Ohm's law, which expresses the relationship of the current to the difference of potential and the resistance of the conductor, holds good, and there can be no question as to the superiority of copper over iron, the latter having six times the resistance of the former; also the discharge would traverse the whole interior mass of the conductor.

But if the discharge is alternating or oscillatory, then the conditions will be changed in two important particulars:—

Firstly—The ordinary law dealing with the resistance of the conductor is no longer applicable; in addition to its true specific resistance it will have a spurious resistance, or what is better known as "impedance," which increases with the frequency of the alternations.

Since these oscillations in the case of lightning are probably at the least a million per second, this impedance may become so enormous as to practically swamp the slight difference in the ohmic resistance of iron and copper. It is in fact so great that a large portion of a discharge will strike across an air gap in preference to traveling through a short length of thick iron or copper wire.

In Fig. 4, the terminals of the Whimshurst machine *M* are joined to the inner coatings of two Leyden jars, having a spark gap *A* in circuit. On working the machine, the jars are charged and discharged through this gap, the outer coatings of the two jars standing on the table.

If these outer coatings be now insulated and another spark gap *B* placed between them, then each time we get a spark at *A*, we also get one at *B*. If these outer coatings be now connected by a short length of copper wire, the sparkling still occurs at *B*, although the resistance of the air gap must be thousands of times greater than that of the copper wire.

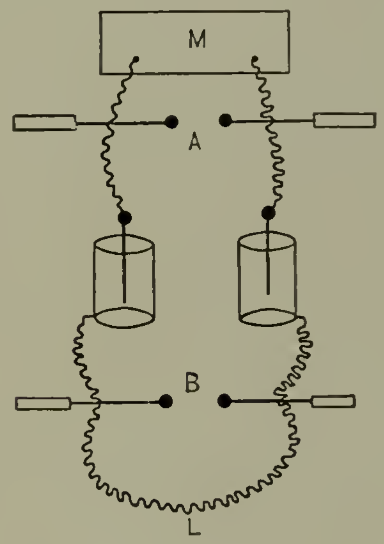


FIG. 4.

With the knobs *A* at a distance of 10 centimeters (3.9 inches), and the knobs at *B* at 20 centimeters (7.8 inches), a discharge takes place.

Now, join the outer coatings of the jars, or knobs *B*, by an alternative path *L*, composed of No. 1 copper wire having a resistance of 0.025 ohm. Then *B* will spark when separated 14.3 centimeters (5.6 inches). If a No. 1 iron wire of .086 ohm resistance be substituted, *B* will not spark until the distance is reduced to 10.8 centimeters (4.2 inches). Hence, the iron wire, having about three and one-half times the ohmic resistance of the copper, acts as a better conductor to this kind of current than the copper one.

Moreover, it can be proved that an alternating current tends to travel on the outer portion of a conductor, the interior portion being practically inoperative, thus indicating that while the specific resistance of the conductor is of minor importance its shape is not so, the larger the surface the better; we should therefore use flat

tapes in preference to circular rods or ropes.

Secondly.—If the lightning flash is oscillatory, then each discharge must set up waves in the ether, and, given a suitable receiver, sparks may occur at this receiver during a discharge through the conductor, although the receiver may be totally unconnected with the conductor, and at some distance away.

In Fig. 5, the Whimshurst machine *M* is joined through a spark gap to the inner and outer coatings of the jar, each coating also having a wire attached to it; these wires lie on the table like the rails of a miniature railway, and have a sliding bar which

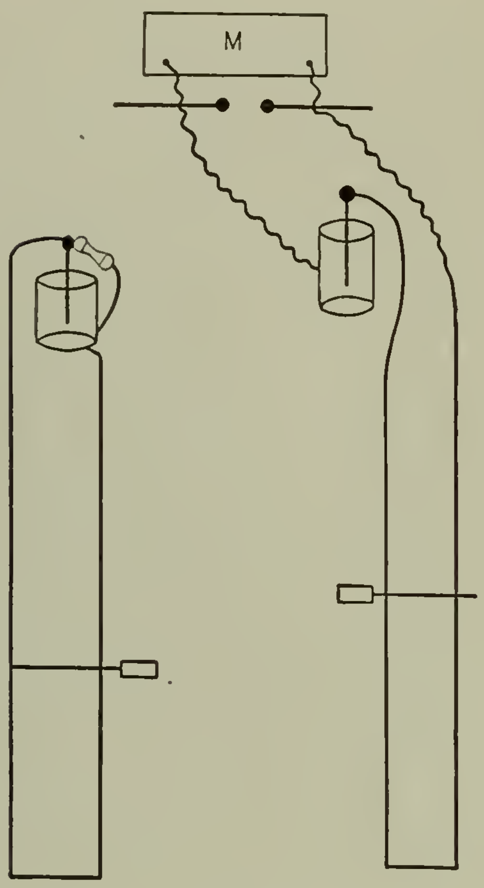


FIG. 5.

can be moved along them. At the far end of the table is placed a similar jar with two wires and slider, the two coatings of the jar being also connected to the ends of a vacuum tube; therefore, each time this second jar discharges, the tube will be lighted.

On starting the machine, the first jar discharges through the gap, but no effect is produced in the second jar and vacuum tube; but by moving the slider along the rails of the first jar, a point is reached at which the second jar responds, and the tube is illuminated. On moving the slider still further along the rails, the light disappears, but it can be re-established by moving the slider attached to the rails of the second jar; in fact, what is done is to tune the two jars, precisely as two instruments are tuned up in an orchestra. We have equalized the capacities of the two jars, and they respond to each other.

Wherein does this apply to our lightning conductor? It certainly proves that the Leyden jar discharge is oscillatory, and if it is true (as asserted) that a lightning flash is also oscillatory, it follows that any two masses of metal, say two iron girders in a building with a suitable gap between them, may be in resonance with a conductor, and liable to spark into each other owing to the oscillations occurring in the conductor during a lightning flash.

Probably we have here the true explanation of the origin of the fire in the cellar of the Dolphin Hotel, at Chichester, previously referred to, the proximity of the gas and water pipes furnishing the necessary conditions for the secondary sparking.

Such is a brief description of the present state of the great problem of protection against lightning—a subject characterized by Lord Kelvin as "tremendously interesting." In the discussion following Sir Oliver Lodge's paper, before the Institute of Electrical Engineers, his Lordship, referring to the professor's suggestion that "the cheapest way of protecting an ordinary house is to run common galvanized-iron telegraph wire up all the corners, along all the ridges and eaves, and over all the chimneys, taking them down to the earth in several places, and at each place burying them in a load of coke," said, "Multiplying the mains by connecting a large number of comparatively small wires, instead of one close conductor, does seem to me to be an important practical suggestion. I would take these galvanized-iron wires—and the more of them the better—down all the corners, and wherever you can get them, and connect every one of them to a water pipe; an ordinary house can, I believe, be made exceedingly safe by connection with the water pipes. I would connect all pieces of metal to each other, and to the earth if you can; but if you cannot (in the absence of water mains) connect each of them to an earth, then connect them to the lightning-conductor, and give the latter a good earth."

Such being the opinion of one of the greatest living authorities on electrical science, it is evident that the efficient protection of even an ordinary dwelling house is not the simple matter usually supposed, and ought not to be regarded in the same light as running a few yards of spouting; while in the case of large buildings the problem is far more complicated, and each case requires careful study. Again, owing to the multiplicity of electric lighting, traction, telegraph and telephone wires at the present time, either attached to, or led into buildings, the danger is materially increased.

In the absence of such wires a building is liable only to damage by local thunderstorms, but given such wires, radiating over a considerable area, the effects of a storm raging miles away may manifest itself in the interior of the building in which such wires terminate. We have a well-authenticated case of a man engaged up a telegraph pole, under a perfect cloudless sky, being instantly killed by shock, the actual storm occurring 40 miles distant. The writer is perfectly aware that most telephonic instruments are provided with so-called "lightning protectors," but personally always gives the telephone instrument a wide berth during a thunderstorm.

By way of a summary, we shall be safe in adopting the following suggestions:—

1. All parts of a conductor should be of similar material.

2. Avoid joints as much as possible, also sharp bends and curves, but allow for expansion and contraction.

3. Iron is as suitable as copper—except for oxidation—flat ribbon being better than round rod or rope.

4. A good and deep earth should be provided, independent of gas or water mains; and if the conductor at any part of its course goes near such gas or water mains, connect it to them.

5. If the place to be protected has water or gas pipes inside it, the conductor should be connected to their underground mains.

6. The neighbourhood of indoor and fusible gas pipes should be avoided in erecting a conductor.

7. A number of short points along a ridge are better than a few tall ones.

7a. All prominent parts of a building are liable to be struck, and each ought to have a rod running along it.

8. No complete security can be obtained unless the whole building be metal lined, floor and all; failing this, connect all pieces of metal to each other, and to the conductors, having good earths.

9. All installations of lightning conductors ought to be periodically inspected and tested, using proper testing instruments—the ordinary so-called "test" made by using a battery and galvanometer or "lineman's detector," being of no value for testing the resistance of earth connections.

We thus see that the conditions of what constitutes an efficient conduc-

tor are continually changing, and the sooner architects, builders, and fire insurance companies realize this fact the better it will be for the security of life and property.

In this paper the writer has confined his remarks to the protection of buildings from the destructive action of lightning discharges; but the enormous number of telegraph and telephone wires leading into buildings at the present time, together with the introduction of overhead trolley wires, and high-tension electric power distribution cables, have enormously increased the facilities for damage by lightning.

Testing Insulated Cables by Means of X-Rays

According to "The Scientific American," a Berlin electric company has lately brought out a novel apparatus for testing insulated cables by means of X-rays. Up to the present time it has been impossible to verify the insulating qualities of the cables and their conductibility except by measurements which are carried out with electrical instruments, and the process is often a long or difficult one. With the new instrument the cable may be examined at once, and the experimenter may be said to actually see the insulation of the cable, by means of the rays. The cable is made to pass over two pulleys which are fixed at the upper part of the instrument. An X-ray apparatus projects the shadow of the cable upon a fluorescent screen as it passes along. The impurities and air-bubbles in the insulating layer are clearly visible on the screen. In practice the apparatus is made portable, so as to be used in a cable factory. A large case mounted upon wheels contains all the apparatus, with the two sheaves for the cable on the top. Underneath the cable is the X-ray tube and above it the fluorescent screen. The cable is unrolled slowly and is examined as it passes across the apparatus.

Japan, being a mountainous country, has numerous water-falls, promising for electrical development. Thirty per cent. of all the electric plants in the country are operated by water power.

An electric line has been installed in the Loudon Park Cemetery in Baltimore, Md. The tracks will connect with those of the street railway, and a funeral car may be run directly up to the receiving vault.

Getting New Business for Electric Central Stations

By R. L. GOODALE

A Paper Read at a Recent Meeting of the Colorado Electric Light, Power & Railway Association

In going out after new business and making an effort to increase your income thereby, no matter how small your town, a little system (and often large doses taken frequently) is the proper course to pursue.

This matter of system should first be applied to a systematic canvass of your commercial and residence districts, including every house that can be reached in any way by your lines. Information should be secured as to whether or not the house is wired and has the fixtures, with any information that may lead to securing these parties for consumers, or if already consumers, to selling them at some time a current-using device.

This information can be kept on cards filed in very inexpensive drawers or cabinets, and should be kept up to date as closely as your consumers' ledger is kept. This gives you a chance to go to a man knowing what he already has and almost what he needs.

For new business you must often look to new current-using devices and appliances—appliances that may not be new to you, but to your consumer or prospective consumer.

In looking up the matter of current-using devices, a wide field is opened up, and although the larger cities will use more varied appliances and have a larger field for each, yet the smaller town has its field, and it takes only a little hustling to find out what that field is.

It is not within the possibilities for the writer to mention all the appliances that will be worth trying in a town, but it is hoped that some of those mentioned may appeal to someone and be productive of good results to his company.

The general field for work along this line may be divided for convenience into a few general heads, as follows:—

1. Commercial power business, including large and small installations of motors for varied purposes.

2. Sign, window and decorative lighting.

3. Residence lighting and appliances.

As a general thing, the start is often the most difficult part of introducing any special device, and is often the only time when a central station management need make any special concession to a consumer.

A consumer using other methods of power is often a little slow about adopting an electric motor in exchange for his old method, even if he does not succeed in getting the best results out of it or is not entirely satisfactory to him. In nearly every town you will find small printing establishments operating small job presses by foot power, and the slower the man the more fertile he seems to be in excuses as to why he should not change to an electric motor drive. Some of these men can only be convinced in one way, and that is to show them. It doesn't cost much to have a motor in stock to install and make a demonstration with, and it is productive of good results, even if you don't sell a motor every time it is installed.

Often the first motor installed and giving satisfaction, is the only thing necessary to open up a small, or, possibly, a large field for the consumption of your current. Any appliance installed and giving satisfaction is a better advertisement to that line of the business than any paid advertisement that you can get out.

For small motors there is another opening at blacksmith and carriage shops in the forge blowers. They are not expensive to run, and any blacksmith will appreciate the saving of labour that it will give him. The motor-driven blower is a good wedge to start the blacksmith with, and if he is at all progressive you will find it easier to sell him motors to operate his drill-press and other small power-using tools and machines.

In putting out special appliances of this kind, if you approach the more progressive man in a special line of work, you will not have very much difficulty in getting him to let you put an appliance in to try; and if you have picked your man well you will find he will keep it, and not only that, but "boost" it for all there is in it.

The original cost, even if it is high, does not always stand in the way of the sale of an appliance. In certain cases a man in a well-established business will pay a big sum for an appliance, simply because it will bring him big results. A case in point is a barber in Colorado Springs who is very slow to take up anything new. He was approached by a traveling man from a barber's supply house who induced him to buy a

facial massage machine. This machine cost him $125 on the installment plan, and it represents a pretty good outlay for a slow man to make on a new appliance. Now that he has it, it would be hard to induce him to part with it, and he gives an average of about ten treatments a day at 35 cents a treatment. His current for this number of treatments will not run more than from 8 to 12 units a month, and so he thinks he has a good thing. This item is not a large amount in itself for the company, but it is one of the many ways that in the aggregate mean more business.

The field in large motors is so large and varied that it cannot be more than mentioned; but you will know of business that could be swung to a motor basis in your own town, and the thing to do is to go after it and get it. In some of these cases there may be only a small margin of profit, but they all add their mite to the general welfare and progress of the station.

The subject of sign and window lighting opens up an immense field for the use of current, and if presented in the right way will take with almost any merchant. Provided your town has saloons, you have a good basis to start on for a sign campaign. The saloon men don't advertise much, if at all, but here is a method by which they can advertise and at a time when it will do them the most good and bring them the most trade.

Here is absolutely a new field for the consumption of current, viz., advertising, and if presented to the consumer along absolutely advertising lines, it will be one of the easiest methods of getting new business.

You must not allow a consumer to believe that he is spending his money for lighting when you sell him a sign. Compare a sign costing him $15 a month to the amount of space that the same money will buy him in the papers, and he will readily see that he has a cheap and most effective method of advertising.

The man who keeps open his place of business at night is not the only one to profit by a sign. The next man is the merchant who closes at, we will say, 6 o'clock. He has a good front and we will hope that he appreciates the advertising value of it. Why should he not keep his windows well lighted, as a pedestrian will look in at a well-lighted window at night when he will pass it in the daytime? Add to that an attractive sign, well lighted and hung across the sidewalk, and he will have something that will draw the people. His windows will show them what he has, and his window lighting, if properly arranged, will make his goods look so attractive that they will come back and buy.

We all, sooner or later, get up against the merchant who says he does not light up because there is no one on the streets; but you know and he will know, if he stops to think of it, that the people will not walk on dark streets. It makes no difference whether the city is New York or a village, the people will walk up the well-lighted streets, and "pass up" the dark ones.

The merchants are the ones to make the start with, and you will have to help them. One of the ways is to light a sign for a certain number of hours a night, controlling the turning on and off by a patrolman or time switch, making a flat rate, and, if necessary, putting the sign on a weekly basis and sending a collector to collect the bill on Monday morning before the banks are open. The general sign rate is about one-half the regular gross rates for current, and when the current is used in an entirely new field and in a new demand it is well worth getting at that price.

You will find many sign companies ready to make signs on their own or your designs, but we have found that we can build a sign, or have it done by local supply houses, cheaper than we can ship it in. The matter of sign design and construction will not take very much work to study up, and the sign catalogues will show you what other cities are doing in the way of signs.

Many central station managers, representing both large and small plants, who have taken time to analyze the value of sign advertising have come to the conclusion that it is a good thing to "boost," and as the original cost of a sign often stands in the way of a merchant installing one, they have reached the conclusion that it is well worth the money spent to furnish free signs and make a two years' contract with the merchant.

How many of your line extensions will give you the return that the investment in a sign will bring? The sign that brings you in $15 a month means $180 a year, and will cost you not more than $60. It is worth hustling for, and is usually not so hard to land as a residential extension that will give you $60 income for a $180 line cost.

Don't overlook your window lighting, but boost it along the lines of advertising and not those of lighting. A merchant will sometimes pay $100 a month for newspaper advertisements and kick at a $5 bill for lighting his windows, when his windows well lighted will bring him more business.

On decorative lighting sets and stringers there is a small or large field, according to the size and progressiveness of your town. If you want to sell a few of these sets it may take a long time to dispense of them. For special sales or Christmas decorations have a few of these sets and rent them out. The decorative sets will sell in the residence districts, especially at Christmas time, and if brought then, the consumer can be induced to use them at other times of celebration.

To get into the residence possibilities for new business, the writer believes that one of the good fields that can be worked in practically any town is the electric laundry iron. A good laundry iron of from five to six pounds can be bought now for from $4 up, and manufacturers are now working along the lines of heating units that can be renewed without sending the iron back to the factory. It can be used for general laundry work in a residence, and for a family of from two to four will use only from ten to fourteen units per month. They appeal at once to the men, as well as the women, as an economy, and not an expense, and they will sell rapidly if put out right.

If you have a show room, you may find it rather difficult to get people to come and look at an iron; but just take the iron out on ironing day and install it, and tell the people that you want them to try it for thirty days. Explain to them the economies of an electric laundry iron, and at the end of the thirty days show them their bill, and unless it has gone up more than a couple of dollars you will find that you won't have 5 per cent. of your irons returned. Sell them at cost and install them at cost, but get the irons out in commission. They will be used the year around, and any single appliance that you can put out that will not bring in from $18 to $24 worth of income a year is a good thing.

The one feature that has stood in the way of the general use of the electric laundry iron is the renewal of the heating unit when it burns out, and, as was said before, this matter has been overcome, and there is an iron on the market that is reasonable in price and which can be renewed at a small cost and small expenditure of time, by anyone familiar with electrical or even mechanical contrivances.

The writer knows of a town in

Colorado where the company had sold a good many small motors for family washing machines, but had not sold an electric laundry iron. It would seem that you could sell more laundry irons at $5 than washing machine motors at $20 to $40, and the iron would bring in more income in a year.

The sewing machine motor should have a small field of usefulness to the consumer and add its part to your welfare. Keep trying new lines and new appliances, and you will find that you will hit the right thing if you will only keep everlastingly at it.

There is only one more matter, and that is "publicity." Keep your business before the people as much as you can, and in as many ways as you can afford. Don't let your newspaper advertisements get dead, but change them frequently. They may not be all of the best quality, but you will find that the contrast between the good and the poor will draw attention to them.

As this is not a paper on advertising methods, the writer cannot go into the matter of advertising, but wants to impress the fact that if new business and more business is wanted you must give it as much publicity as you can. Business does not come to many of us; we have to go out and get it.

Electricity Supply in Great Britain

IN an article on the supply of electricity in bulk, the London "Engineer" says that the problem of distribution affords one of the principal reasons why so little has been effected in the way of establishing great central generating stations in Great Britain.

"Abroad," we are told, "the conditions are so far different, or the necessities are so great, that the solution of the problem seems to have been found long since. The difficulty, or assumed difficulty, is insulation. The voltage must be high. In Germany no hesitation is felt in taking bare wires right across country on lofty poles. Where the wires cross roads, safety nets are put up under them, so that in case of breakage they may not fall to the ground. In the United States no one dreams of making any difficulty about the matter; power is wanted; it can be transmitted along a wire; put the wire up, the thing is done.

"The climatic conditions are in several respects better than ours, though, in others worse. We have not snow and ice to contend against; but we have damp, and rain, and fogs, and insulation is apt to fail. We have very recently described the best types of insulators that have yet been put into use. But for very high tension much remains to be accomplished. In fine dry weather current is manageable enough; but when the atmosphere is just a cloud supersaturated with water, the electrician may well be driven to his wits' end; yet the problem is by no means impossible of solution. So far little or nothing has been attempted here in the way of devising supports for wires carrying 40,000 or 50,000 volts in the air. To put the wires underground is quite out of the question, from considerations of expense, if nothing else. But what has been done in the United States can be done here."

An Edison Story

HERE is another Edison story,—told in the "World's Work."

When Edison was a boy, so the tale goes, selling papers on a train between Huron and Cleveland, he became so interested in electricity that he has never been able to let it alone since. Unfortunately his spare time off duty was not enough for his experiments, says the "World's Work." He urged his father to let him sit up nights and play with the telegraph; but Mr. Edison, senior, believed in early rising and early going to bed, and Thomas was sent to his room promptly at nine, while his father sat up two hours longer to read the papers the boy had brought home.

Those two hours tempted the boy, and at last he hit on a plan for securing them. His chum lived about two hundred yards away, beyond an intervening orchard. The two boys rigged up a telegraph circuit between their rooms. Young Edison made batteries of preserve jars. The day after it was in order he gave the extra papers to his chum, and when night came there were none for his father to read.

Mr. Edison seemed much disturbed by the loss of his daily reading matter, and by 9 o'clock, when it was time for Thomas to go to bed, he was very restless. Then the boy made a suggestion.

"All the papers are down at Dick's," he said. "But Dick and I have a telegraph line between our rooms. I think perhaps I can call him up and get the news."

Accordingly they adjourned to the boy's room, and soon had Dick on the wire. Then while beyond the orchard Dick read from the paper and sent the messages by telegraph, young Edison took down bulletins and handed them to his father. Bedtime was forgotten, and it was after 11 o'clock before the father was ready to quit.

After that he seemed to have no more worry over the effect of late hours on his son, and young Edison had his time to himself for electrical experiments.

An Interesting Gasoline-Electric Car

IN sparsely settled districts where the cost of operating a steam-drawn train is excessive, and the immediate investment of capital for an electric service unwarranted, there has arisen a need for a self-contained car which shall be independent of a feeder system, and at the same time be cheaper to operate than the ordinary locomotive and train. For this purpose, the General Electric Co., in conjunction with the American Locomotive Co., at Schenectady, N. Y., recently completed a gasoline-electric car, which presents many features of interest as a proposed solution for this go-between. The car and the generating unit are shown in the annexed illustrations.

The first trial run of this novel car took place on February 3, when a successful trip was made from Schenectady to Saratoga, N. Y., and return, over the lines of the Delaware & Hudson Railroad. During the trip several important features of this method of driving were demonstrated. While the car was not designed for high speed, the average running time was about 35 miles an hour, and several times the car attained a speed of over 40 miles an hour. The smooth and rapid acceleration, as well as the complete absence of vibration which might be thought to accompany the use of a gasoline engine, were most favourably commented upon by the engineers present.

This car consists essentially of a gasoline-driven electric generator, furnishing current to electric motors geared to the driving wheels and controlled by a method similar to that employed in the ordinary electric car equipment. The car is of the combination type, comprising a passenger compartment, smoking room, baggage room, engine room, one toilet and a motorman's compartment. It is 65 feet long over buffers, and equipped, weighs 65 tons. A complete controlling equipment is located at each end of the car, one controller being in the engine room, and a similar controller in a compartment at the other end.

The car has seating capacity for forty passengers, including seats for twelve in the smoking room. In gen-

eral, it is built on the lines of a standard Delaware & Hudson passenger coach, and is handsomely finished. The passenger compartment is decorated in mahogany with a birch wainscoting, the smoking room in quartered oak, and both the baggage and engine rooms in painted poplar. The outside of the car is painted and lettered in the standard Delaware & Hudson pattern, and Gould pattern bumpers and drawbars are provided.

The gasoline engine for this car was built by the Wolseley Tool & Motor Car Co., Ltd., of Birmingham, England, and is considered the most powerful unit yet constructed for this class of work; it develops 160 B. H. P. at a speed of 450 revolutions per minute. The cylinders, six in number, are horizontal opposed, of 9-inch diameter and 10-inch stroke. All valves are mechanically operated, and the cylinders are water-cooled. Hitherto, difficulty has been experienced in starting internal combustion engines of this size, but in the present case this has been entirely overcome by using shells filled with black powder to provide the initial charge in one cylinder.

On starting the engine, the shell is fired by a hand trigger, the whole being similar to the breach mechanism of a gun. Jump-spark and low-tension ignition are both provided, current being furnished to the latter by a small magneto driven from the engine shaft.

The volatilization of the liquid fuel is produced in two carburetors which form an integral part of the engine. Each carburetor supplies three cylinders and is equipped with two float feed chambers. The chambers are identical and are of the usual needle-valve type. Very flexible arrangements are provided to govern the air supply so that it may be taken from the atmosphere or from the crank chamber, or from both according to the conditions required. The mixture is heated to the required temperature in a small chamber, which itself is warmed by the exhaust. In all details the engine is very complete. The lubrication is especially so, being force-feed for main bearings and pistons and drip-feed for all other working parts. Gasoline is stored in steel tanks beneath the car, and the burnt gases pass through the roof into mufflers, from which they exhaust into the air. The cooling system for the cylinders consists of radiating tubes, located on the top of the car. Water for cooling is contained in the engine base.

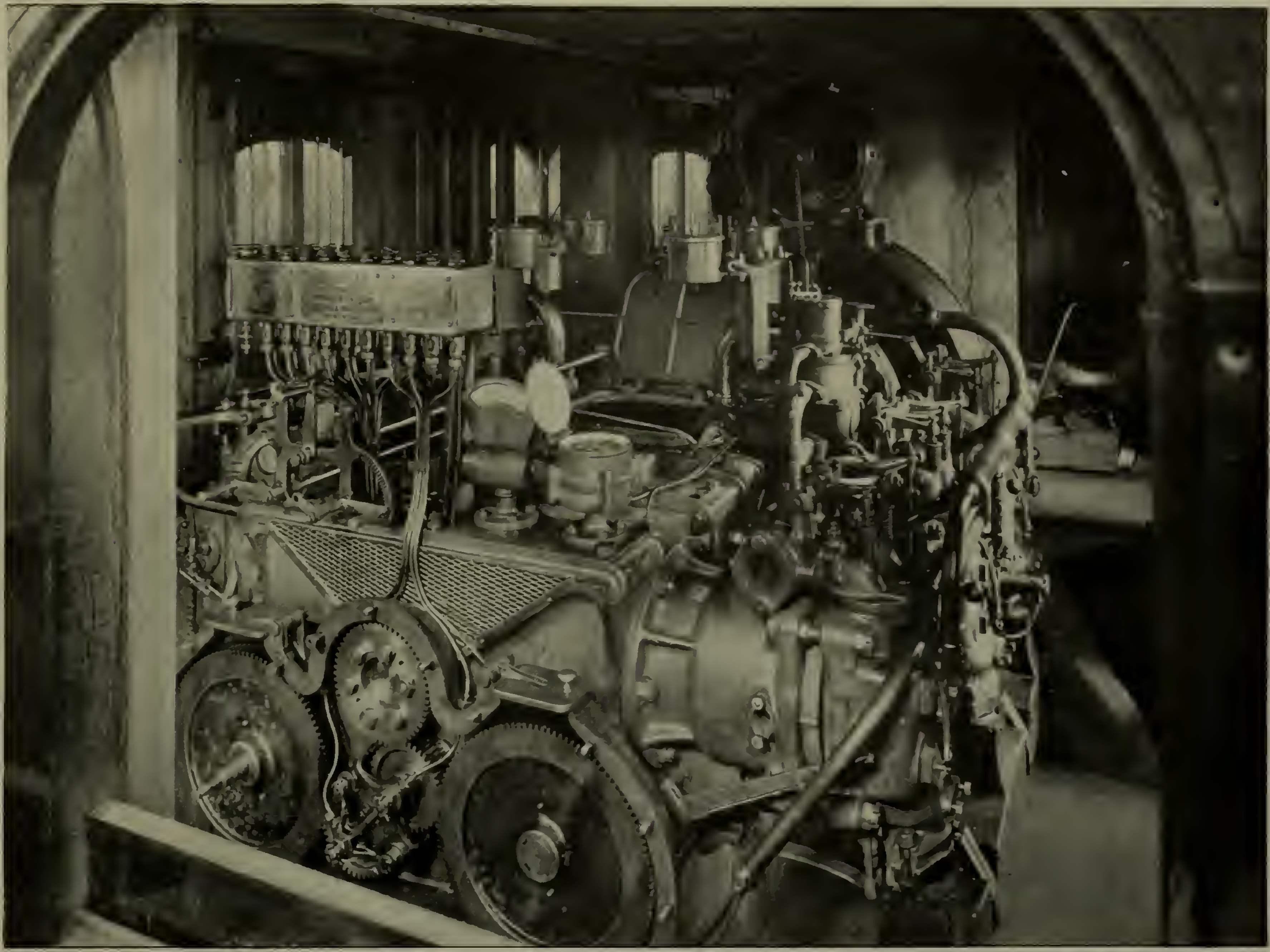
For heating the car, a three-way cock is provided which by-passes the circulating water through the usual pipe heating system within the car.

The transmission is electrical, consisting of a generator and standard railway motors. Current is furnished by a 120-KW., direct-connected, General Electric six-pole generator, designed for 600 volts. This generator is provided with commutating poles, which, in connection with the method of voltage control, permit a very flexible operating system. The advantage of commutating poles is evident when it is considered that the field excitation at starting is weak, and a large current at low voltage is required to give the necessary starting torque. Owing to the peculiar operating conditions of this system, the generator, while retaining the characteristics of a shunt-wound machine, is separately excited by a $5\frac{1}{2}$-KW., two-pole, compound-wound exciter working at 110 volts. This is located on top of the generator and is driven by a Morse silent chain.

There are two G. E. 69 motors of standard railway construction similar to those used on the Interborough Company's lines in New York.

For regulating the speed of the motors, as mentioned above, voltage control is used; in other words, the speed of the car is governed by varying the field strength of the generator. With this method, the speed of the engine remains constant after acceleration. The controller is semi-automatic, and can be set for any predetermined maximum acceleration. It is arranged for series-parallel control, the motor connections being

A GASOLINE-ELECTRIC CAR ON THE DELAWARE & HUDSON RAILROAD. BUILT BY THE GENERAL ELECTRIC COMPANY IN CONJUNCTION WITH THE AMERICAN LOCOMOTIVE COMPANY, AT SCHENECTADY, N. Y.



A VIEW OF THE ENGINE COMPARTMENT

changed from series to parallel by the reversing handle. This latter has five positions, "series ahead," "parallel ahead," "off," "series reverse," and "parallel reverse." Arrangements are provided to prevent the motor connections from being changed from series to parallel until the resistance is put into the field circuit of the generator.

Further operating details comprise a General Electric combination straight and automatic air-brake equipment, and a special lighting equipment. Meridian lamps are used, equipped with Holophane reflectors, manufactured by the Holophane Glass Co., of New York, the whole affording a very satisfactory system for car lighting. The headlights are supplied with 100-candle-power incandescent lamps of the stereopticon type, one for each end of the car.

The trial trip of this car demonstrated the practicability of this equipment, and was entirely satisfactory to the engineers and officials present, so far as the tests indicated. The opinion was expressed that this was merely a step toward the final electrification of all service. A gasoline car would be useful in establishing a passenger traffic, but eventually the motive power for operation would be electricity.

The photograph of the car from which the illustration is reproduced, was taken after the arrival in Saratoga. Among the officials present from the Delaware & Hudson Co., were:—Axel Ekstrom, consulting electrical engineer; J. H. Manning, superintendent of motive power; J. W. Burdick, passenger traffic manager; Jas. McMartin, chief engineer; J. B. Dixey, assistant to second vice-president; W. J. Mullin, assistant to second vice-president; D. F. Wait, superintendent of Susquehanna division; E. F. Peck, manager Schenectady Railway Co.; and from the General Electric Co., E. W. Rice, Jr., technical director; W. B. Potter, chief engineer; J. R. Lovejoy, general manager railway department; J. G. Barry, assistant manager railway department; W. J. Clark, manager transportation department; E. D. Priest, A. F. Bachelder and H. G. Chataine, of the railway engine department; F. H. Gale, advertising department.

The Illuminating Engineering Society

THE Illuminating Engineering Society, previously referred to in these columns, was formally organized at New York last month; a constitution and by-laws were adopted and officers elected. These latter are:—

President, L. B. Marks; vice-presidents, Dr. C. H. Sharp and A. A. Pope; managers, Dr. A. H. Elliott, W. S. Kellogg, E. C. Brown, F. N. Olcott, W. D'A. Ryan and W. D. Weaver; secretary, E. L. Elliott; treasurer, V. R. Lansingh.

Applications for membership may be addressed to E. L. Elliott, secretary, 25 Broad street, New York. The annual dues are \$5.

Any person interested in the object of the society is eligible for membership, this object being the advancement and dissemination of knowledge relating to the science and art of illumination.

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Leading Articles

Technical Advice in the Courts

THE appointment by Judge Grosscup, of the Federal Court, Chicago, of John M. Harlan as his special legal adviser in connection with the receivership of the Union Traction Co. of that city, establishes an interesting precedent in the relations between the judiciary and modern industrial conditions. It has long been the custom of contending parties in law courts to introduce expert witnesses in support of their respective claims, but the securing of independent technical advice by the judiciary has rarely been practiced. There is not the slightest doubt that if technical advice should be more freely sought in involved industrial cases, particularly those in which engineering knowledge is essential, the machinery of the law would be lubricated in one of its stiffest joints, to the lasting acceleration of certain classes of legal decisions.

Such seeking of advice from professional sources would in no wise be an admission of any lack in judicial ability, for in the modern industrial world specialized knowledge is on every hand essential to success. It is one thing to determine the interpretation of the law, and another to clarify a technical subject under litigation, and few men possess the mental capacity to do expert work in two such professions at once. Judge Grosscup's action cannot but be regarded as evidence of an open mind by the entire engineering profession, even though the precedent established bears only an indirect relation to engineering retainers.

Power Station Unity

ONE of the noteworthy features of early central station design was the great variety of apparatus usually installed under a single roof. Many of the pioneer plants were veritable Noah's arks in point of equipment, and as a result the operating and maintenance problems presented no little difficulty. Innumerable spare parts were required, for few were interchangeable; breakdowns could not be remedied with the speed of to-day; wiring was difficult to follow; and the switchboards consisted of a heterogeneous assortment of panels claiming little flexible relation to the operating scheme of the plant as a whole. Generating units were small and numerous, while pulleys, belts, and shafting ran amuck from one end of the plant to the other.

A large part of this complication was necessary for the reason that consumers' apparatus was in a formative period. Ten years or so ago the direct-current motor was a fairly well standardized piece of machinery, but the alternating-current motor and alternating arc lamp were not in general commercial service. The induction motor, to be sure, was a familiar type, but the great bulk of central station work was performed by continuous current, supplemented by single-phase alternating-current service for house to house incandescent lighting over wide areas.

It was long ago realized that it would be a great gain in power plant design and operation to reduce the number and variety of circuits leading from the generating plant to the consumers, and as alternating current applications developed, the generating plant grew simpler, until to-day we find a number of central stations selling alternating current alone, or on the point of replacing all their direct-current equipment by alternating apparatus. In the street railway field we have, of course, long enjoyed the maximum unity of power plant design, often to the entire exclusion of alternating current, but it is only lately that central stations have reached the point where the generation of a single kind of current at one voltage meets all the requirements of commercial service.

Thus, the entire lighting and power service of a community may now be derived from a 2300-volt central station generating three-phase current at 60 cycles. The streets may be lighted by alternating enclosed arcs, run in series with incandescents and constant-current transformers; commercial and residence lighting follow the usual multiple system with sta-

tionary transformers at the consumers' premises; and the latter system of distribution takes care of the motor load, which is largely of the induction type. Electric heating devices are equally serviceable with the alternating supply, provided they are made with non-inductive resistances. The variable-speed alternating single-phase motor solves the problem of machine tool-driving at different rates, elevator work, etc. We do not, by any means, intend to state that the foregoing outline is the solution of every central station problem; the point is simply this, the design of both direct and alternating equipments has now reached a stage where a single broad system is equal to practically every technical requirement.

Telephone Receiver Research

THE telephone receiver is justly famous as one of the most delicate electrical instruments ever invented, and its marvelous simplicity has challenged the admiration of every appreciative user who has investigated its construction. As an indicator of minute currents it surpasses all other apparatus in its ability to withstand abuse and respond at the same time to magnetizing forces so feeble that in the great majority of galvanometers no indication whatever is apparent. No better proof of the sensitiveness of the receiver is necessary than its response to the minute changes in amplitude and vibration rate corresponding to the personal peculiarities of a voice 1500 miles away. With so effective an instrument there has not been, until lately, the incentive to analyze its performance which is usually present with less perfect apparatus, although it is probable that the Bell interests have possessed themselves of a large amount of data concerning its operation upon different kinds of circuits.

At the present time a scientific study of the amplitude of vibration of a telephone receiver diaphragm under various conditions is being made at Clark University, Worcester, Mass. The apparatus employed to measure these exceedingly minute movements consists in the main of a modification of the Michelson interferecometer, adjusted to measure the width and movement of colour fringes caused by the interference of light waves reflected from a small mirror attached to the diaphragm of the receiver under test. The receiver is connected to a battery and transmitter located in another part of the laboratory, and an equipment of tuning forks, adjustable resistances and inductances enables a great variety of conditions to be studied, including the effect of sounds caused by musical instruments, the human voice, etc. Movements representing an amplitude of vibration of one-millionth of an inch are measurable in this apparatus, and those in charge of the investigation are hoping to secure results of considerable interest in the way of comparisons between different receivers.

An investigation like this ought to throw much light upon the relations between receiver design and sensitiveness and also upon the effect of inductance, capacity, resistance, pitch, and loudness in the sounds at the transmitter. The opportunities for extended research on this basis certainly are many. There are many unsolved problems in telephony. The long-distance lines have not as yet reached much beyond Omaha from New York and Boston, and transcontinental communication by telephone is as yet but a dream.

It is impossible to believe that the electrical engineer will finally rest content with anything short of ocean telephony itself, although the realization of this triumph over distributed capacity seems far away indeed. Commercial conditions, no doubt, are largely responsible for the failure of the long-distance telephone interests to cross the Colorado line, but with the development of the Far West this advance is sure to come, if indeed it be not close at hand.

In the light of present knowledge the physical characteristics of the circuits are the limiting factors in the technical problem of 2000 or 3000-mile telephony. With such an apparatus as that which J. T. Rood is employing at Clark University it ought to be possible, for some one with sufficient time for such investigations, to attack the problems of telephonic transmission from both ends at once, for the measurement of vibration amplitudes of from one ten-thousandth to one-millionth of an inch enables results of extraordinary accuracy to be attained. Even though the obstacle to telephoning over very long distances may lie in the circuits which span many hundreds of miles of diverse topography, it is certainly desirable to learn as much as possible about all the factors which bear upon the problem. The apparatus employed in these experiments well illustrates the usefulness of a scientific discovery or invention in later investigations, showing the dependence of physical research upon all that has gone before.

Aluminium Production at Niagara Falls

NIAGARA FALLS has come to be known as the aluminium center of the country, and that it is to continue as such is evident from an announcement just made that the Pittsburg Reduction Co. has contracted with the Niagara Falls Hydraulic Power & Manufacturing Co. for 27,000 H. P. to be delivered in 1907. The Pittsburg Reduction Co. has also leased four acres of land from the power company, and on this site will erect a fine new works for the manufacture of the white metal.

It is said to be the intention of the Pittsburg Reduction Co. to erect the largest aluminium works yet built, the first structure to be 600 feet long and constructed of steel and cement, in order that it may be thoroughly fireproof. It is intimated, but not verified, that as the works referred to will not cover the four-acre site the company may intend ultimately to erect other buildings thereon for the manufacture of aluminium wire and other articles. In any event it is evident that the new works will give employment to many hands, and that the world's output of aluminium will be very materially increased when this new plant is placed in operation.

The rapid strides made in the manufacture of aluminium are due to the Niagara power development and the erection of the two present great works at Niagara Falls. One of these plants is located on the lands of the Niagara Falls Power Co., and the other is at the edge of the high bank on the property of the Niagara Falls Hydraulic Power & Manufacturing Co. Since aluminium has been manufactured in such large quantities in Niagara Falls the price per pound has been very materially reduced, so that it has become a competitor of copper in the erection of power transmission lines in all parts of the country. The electrical industry has profited largely by the development, and it would appear from this latest enterprise of the Pittsburg Reduction Co. that it sees a very bright future before the metal, the consumption of which is likely to increase greatly when the new Niagara plant is ready to help supply the market. Every day appears to develop new uses for the metal, and the economic production at Niagara will continue to benefit many fields.

The first large hydro-electric power station in Wales is now being installed in the Snowdon district for the North Wales Power Co.

American Institute of Electrical Engineers

Papers at the January Meeting at New York

THE principal topic of the evening at the last meeting of the American Institute of Electrical Engineers, held on January 26, was "Power Plant Economics." Two papers had been scheduled for that meeting, the one bearing the above title, by Henry G. Stott, the superintendent of motive power of the Interborough Rapid Transit Co., of New York, and one on "A Self-Exciting Alternator," by E. F. Alexanderson, of The General Electric Co.; but Mr. Stott's paper, as was to be expected, was of exceptional interest, and even early in the evening promised to take up nearly all the available time. Mr. Stott's paper was substantially as follows:—

POWER PLANT ECONOMICS

Three years ago the steam-power plant for the generation of electricity had apparently settled down to an almost uniform arrangement of standard apparatus in which one power plant differed from another only in details of construction of engines, generators, and auxiliaries. As only about twenty years had then elapsed since the first central station was put in operation on a commercial basis, this uniformity of design seemed to indicate that in the near future it would only be necessary to purchase a standard set of power-plant drawings, and make the necessary changes in size of units in order to have a station of the best type known to the art.

The internal combustion or gas engine had from time to time been brought forward as a candidate for the position of prime mover, with every prospect of improved economy in fuel consumption; but with the exception of a few special instances it was not looked upon with favour, as shown by the almost universal use of the steam engine.

After a long period of development a new factor in power-plant design, namely, the steam turbine, was placed on the market in commercial sizes. It is safe to say that during the last three years no other piece of apparatus has had so stimulating an effect upon the power plant. Its effect upon the entire plant has been most beneficial, for it has revived the apparently moribund superheater. This has now been so developed and improved that superheat of 200 degrees or 300 degrees F. can be safely and economically obtained. With the development of the superheater further study of the problem of combustion has improved the efficiency of the furnace, and this most important subject is apparently susceptible of still further development.

One other important result of the steam-turbine development has been the development of condensing apparatus to such a point of efficiency that a vacuum within 1 inch of the simultaneous barometer reading can now be maintained without difficulty.

Another change in the power plant has been the reversion to high-speed generators, resulting in decreased cost of the generator and its foundations, as well as saving in floor space.

Last, but not least, the steam turbine has put the reciprocating engine and the gas engine on the defensive and has actually been unkind enough to throw out hints in regard to the application of Dr. Osler's proposed methods to the treatment of older apparatus.

The reciprocating engine and internal-combustion engine have not been slow in accepting this challenge; they have responded by showing so improved an economy (especially in the gas engine) that the situation has become most interesting to the power-plant designer. It is safe to say that the developments of the next ten years will show very marked improvement in power plant efficiency.

In regard to this development the author wished to direct attention to the basic fact that in power plants one should not look merely for increased efficiency in the prime mover, but should also investigate and analyze the entire plant from the coal to the bus-bars,—first, in regard to efficiency; second, in regard to the effect of load-factor upon investment; and third, the effect of the first and second upon the total cost of producing the kilowatt-hour, which is the ultimate test of the skill of the designer and operator.

EFFICIENCY

In Table I. will be found a complete analysis of the losses found in a year's operation of what is probably one of the most efficient plants in existence to-day, and, therefore, typical of the present state of the art.

TABLE I.—ANALYSIS OF THE AVERAGE LOSSES IN THE CONVERSION OF ONE POUND OF COAL INTO ELECTRICITY

	B. T. U.	Per Cent	B. T. U.	Per Cent.
1. B. T. U. per pound of coal supplied	14,150	100.0	......	......
2. Loss in ashes	......	......	340	2.4
3. Loss to stack	......	......	3,212	22.7
4. Loss in boiler radiation and leakage	......	......	1,131	8.0
5. Returned by feed-water heater	441	3.1	......	......
6. Returned by economizer	960	6.8	......	......
7. Loss in pipe radiation	......	......	28	0.2
8. Delivered to circulator	......	......	223	1.6
9. Delivered to feed-pump	......	......	203	1.4
10. Loss in leakage and high-pressure drips	......	......	152	1.1
11. Delivered to small auxiliaries	......	......	51	0.4
12. Heating	......	......	31	0.2
13. Loss in engine friction	......	......	111	0.8
14. Electrical losses	......	......	36	0.3
15. Engine radiation losses	......	......	28	0.2
16. Rejected to condenser	......	......	8,524	60.1
17. To house auxiliaries	......	......	29	0.2
	15,551	109.9	14,099	99.6
	14,099	99.6		
Delivered to bus-bar	1,452	10.3		

DISCUSSION OF DATA IN TABLE I

ITEM 1.—B. T. U. PER POUND OF COAL SUPPLIED

The thermal value of the coal used is evidently of prime importance, as it affects the cost efficiency of the entire plant. The method of purchasing coal used in the plant from which this heat balance is derived is that of paying for British thermal units only, with suitable restrictions on the maximum permissible amount of volatile matter, ash, and sulphur.

A small sample of coal is automatically taken from each filling of the weighing hoppers, so that the final sample represents a true aver-

age of a boat load of coal. This final average sample is then pulverized and tested for heat value in a bomb calorimeter, after which a proximate analysis is made of another portion of the sample. This method of purchasing coal has been in use for two years, with highly satisfactory results.

ITEM 2.—LOSS IN ASHES

It is doubtful whether a further saving in this item can be made, as the extra care and labour necessary to accomplish any improvement would in all probability offset the saving in coal.

ITEM 3.—LOSS TO STACK

This is one of the most vulnerable points to attack, as the loss of 22.7 per cent. is very large. Recent investigations show that promising results may be obtained by the use of more scientific methods in the boiler room. In practically all cases it will be found that this loss is due almost entirely to admitting too much air to the combustion chamber, resulting in cooling of the furnace. This result is usually produced by "holes" in the fire; these "holes" may be due to several causes, but usually are due to carelessness on the part of the fireman.

Fortunately, a very valuable piece of apparatus has been placed upon the market in the shape of a CO_2 recording instrument. The results of a series of tests made with this instrument have shown that with forced draught the conditions are such that approximately 40 per cent. of the thermal value is being lost. By watching the CO_2 record improvement may easily be obtained, a saving of about 19 per cent. over the above having been made in this way.

In the combustion of the small sizes of anthracite it is necessary to use a draught of not less than 1.5 inches of water; this breaks the crust of the fire in the thin spots, allowing the air to come through in such volumes that an enormous amount of heat is wasted in raising the temperature of the surplus air, and at the same time causing inefficient combustion in the entire furnace.

Records taken from a stoker boiler whilst the recorder was covered up to prevent the fireman from seeing the induction and records taken from the same boiler with the fireman watching the CO_2 indications, showed a saving of over 12 per cent. Later records show that even better results than an average of 11.4 per cent. of CO_2 can be obtained.

From a consideration of these tests it seemed reasonable to assume that the 22.7 per cent. loss to stack can, by scientific methods in the fireroom, be reduced to about 12.7 per cent., and possibly to 10 per cent.

Before the installation of the CO_2 recorder, a long series of evaporative tests was made to determine the most economical draught to carry when a high-grade semi-bituminous coal was burning on the automatic stokers. The results were so remarkable that they were repeated under different conditions in order to confirm them. Since the installation of the CO_2 recorder, however, the explanation is apparent, as the draught giving maximum evaporation per pound of combustible corresponds to the point of maximum CO_2, illustrating the inherent difficulty of maintaining efficient conditions in the combustion chamber with high draught.

ITEM 4.—BOILER RADIATION AND LEAKAGE

The loss in boiler radiation and leakage, amounting to 8 per cent., is largely due to the inefficient boiler setting of brick, which, besides permitting radiation, admits a large amount of air by infiltration. This infiltration will increase with the draught. The remedy for this radiation and infiltration loss is evidently to use new methods of boiler setting, such as an iron plate air-tight case enclosing a carbonate of magnesia lining outside the brickwork.

W. H. Patchell, of London, who recently visited us, has introduced very large boilers, assembling two in one setting; each boiler has a normal evaporation of 33,000 pounds per hour, and in this way cuts down to a minimum the radiating surface per square foot of heating surface. He has also introduced the iron case with magnesia lining, and with good results.

The question of boiler leakage is one in which the choice of the lesser of two evils is necessary; for in the tubular or cylindrical boiler the leakage will undoubtedly be less than in the water-tube type, owing to the smaller number of joints in the water space. But these two advantages are offset by the increased difficulty of construction, and the danger of using large boilers of the tubular type, especially with high-pressure steam.

It is now generally admitted that there can be no more difference in the efficiency of different types of boilers under similar conditions than there can be in electric heaters, press agents to the contrary notwithstanding.

ITEM 5.—RETURNED BY FEED-WATER HEATER

The importance of getting the feed water to the maximum temperature obtainable is generally recognized, and would seem to indicate that all auxiliaries should be steam driven so that their exhaust may be utilized in the feed-water heater; in this way the auxiliaries may operate at about 80 per cent. thermal efficiency.

ITEM 6.—RETURNED BY ECONOMIZER

Owing to the difficulty of pumping water at temperatures above 150 degrees F., when under pressure, it becomes necessary to install economizers for the purpose of increasing the feed-water temperature to 200 or 250 degrees F. As this increase of temperature is obtained from the waste gases at no expense for fuel, it only becomes necessary to consider the load-factor, as will be shown later, in order to decide whether economizers should be installed or not. In practically all cases where the load-factor exceeds 25 per cent. the investment will be justified.

In deciding upon the size of economizer to be installed it is important to consider first, the influence of the economizer upon the available draught due to the obstruction it offers and also due to the reduced stack temperature; the second important consideration is to equate the interest and depreciation charges against the saving in fuel, and so determine the amount of investment justified in each particular case.

ITEM 7.—LOSS IN PIPE RADIATION

By the use of two-layer pipe covering, each layer being approximately 1.5 inches thick, and sections put on in such manner that all joints are broken, the radiation losses have become practically negligible.

ITEMS 8 AND 9.—HEAT DELIVERED TO CIRCULATING AND BOILER-FEED PUMPS

As these auxiliaries may be either electrically driven or steam driven, it is interesting to note that the thermal efficiency of the electrically driven pumps would be equal to the thermal efficiency of the plant, multiplied by both the efficiency of conversion from the alternating to direct current and by the motor efficiency. In this case, there would be a net thermal efficiency of $10.3 \times 0.93 \times 0.90 = 8.63$ per cent., whereas the thermal efficiency of the steam-driven auxiliary discharging its exhaust into the feed-water heater at atmospheric pressure would be approximately 87 per cent.

ITEM 10.—LOSS IN LEAKAGE AND HIGH-PRESSURE DRIPS

The loss in leakage should be infinitesimal, and the high-pressure drips can be returned to the boilers,

so that practically all the loss under this heading is recoverable.

Items 11, 12 and 17 are probably unavoidable and of so small a magnitude as not to merit much consideration.

ITEM 13.—LOSS IN ENGINE FRICTION

Recent tests of a 7500-H. P. reciprocating engine show a mechanical efficiency of 93.65 per cent. at full load, or an engine friction of 6.35 per cent. As this forms only 0.8 per cent. of the total thermal losses, it is relatively unimportant. Attention is called to the method of lubricating all the principal bearings by what is known as the flushing system, whereby a large quantity of oil is put through all the bearings by gravity feed from elevated oil reservoirs common to all the units; after passing through the bearings the oil is returned by gravity to oil filters in the basement and then pumped up to the reservoir tanks again. About 200 gallons per hour are put through each engine, and of this quantity only about 0.5 per cent. is lost. This method of oiling undoubtedly contributes to the general result.

ITEM 14.—ELECTRICAL LOSSES

As large electrical generators can now be obtained which give from 98 to 98.5 per cent. efficiency, it would seem as if the limit in design had been reached and that hereafter the problem of design is to be merely one of altering dimensions to suit varying sizes and speeds. While this is true as far as the efficiency is concerned, other problems are continually arising, such as the design of generators for an overload capacity of 100 per cent. to meet the demand for apparatus capable of taking care of great overloads economically for short periods, corresponding to peak loads of a railroad or lighting plant.

ITEM 15.—ENGINE RADIATION LOSSES

This source of loss has evidently been reduced to a negligible quantity by the use of improved material and methods of heat insulation.

ITEM 16.—REJECTED TO CONDENSER, 60.1 PER CENT.

This immediately introduces the thermodynamics of the steam engine, a subject so broad that it will be impossible to do more than touch upon some of the most important points in considering steam-engine efficiency.

The efficiency of any heat engine can be expressed by the ratio of $E = \frac{T_1 - T_2}{T_1}$ where T_1 is the absolute temperature of the steam entering the engine, and T_2 the absolute temperature of the steam leaving the engine. Thus, if the initial pressure in an engine is 175-pound gauge, and the vacuum at the low-pressure exhaust nozzle is 28 inches, the maximum thermal efficiency is

$$\frac{837 - 560}{837} = 33 \text{ per cent.}$$

This would be true for any form of engine or turbine working between the same temperature limits.

Actual economy curves for a 7500-H. P. engine show, for the point of maximum economy, a steam consumption of approximately 17 pounds per kilowatt-hour, which is equivalent to 20.349 British thermal units per hour. One kilowatt-hour is equal to 3412 British thermal units per hour, so that the actual efficiency of the steam engine and generator is $\frac{3412}{20\,3.9} = 16.7$ per cent. As then the generator efficiency at this load is approximately 98 per cent, the net engine thermodynamic efficiency is

$$\frac{16.7}{0.98} = 17 \text{ per cent.}$$

The difference between the theoretical efficiency and the actual is then 33 — 17 = 16 per cent., of which 6.35 per cent. has already been accounted for in engine friction, so that the balance of 9.65 per cent. is due to cylinder condensation, incomplete expansion, and radiation.

As the engine friction in a two-bearing engine with high-pressure poppett valves and low-pressure Corliss valves has by careful design been reduced to less than 6.5 per cent. gain cannot be expected here, so that attention must be centered on the loss due to cylinder condensation, etc., amounting to 9.65 per cent., in order to effect any improvement.

Superheated steam is the only remedy at hand, and with it we can probably effect an improvement of 5 or 6 per cent. by using such a degree of superheat in the boilers that dry steam will be had at the point of cut-off in the low-pressure cylinder.

Any greater amount of superheat than this will merely result in loss to the condenser; for it should be remembered that the cylinder losses increase with the difference in temperature between the steam and exhaust portions of the cycle; in other words, the greater the thermal range of temperature the greater the condensation loss. This would seem to point to the use of more cylinders; but this involves additional first cost and friction as well as more space and higher maintenance charges.

SUMMARY OF ANALYSIS OF HEAT BALANCE

The present type of power plant using reciprocating engines can be improved in efficiency as follows:—

Reduction of stack losses..... 12%
Reduction in boiler radiation and leakage 5%
Reduction in engine losses by the use of superheat....... 6%

resulting in a net increase of thermal efficiency of the entire plant of 4.14 per cent., and bringing up the total thermal efficiency from 10.3 per cent. to 14.44 per cent.

THE STEAM TURBINE

A typical economy curve of a steam turbine shows,—first, that the best economy on dry saturated steam is practically equal to that of the reciprocating engine; second, that 200 degrees superheat reduce the steam consumption 13.5 per cent. But calculating the total heat units in superheat from $H_1 = H + 0.48\ (t_2 - t_1)$ the British thermal units per kilowatt-hour are 20.349 for dry saturated steam, whilst for 200 degrees superheat they are 19,008, or a net thermal saving of 6.6 per cent. The shape of the economy curve, however, is much flatter than that of the reciprocating engine, so that the all-day efficiency of the turbo unit would be considerably better than that of the reciprocating engine, with the other great advantage of costing approximately 33 per cent. less for the combined steam motor and electric generator.

HIGH-PRESSURE RECIPROCATING ENGINE WITH LOW-PRESSURE TURBINE ON ITS EXHAUST

The inherent principles involved in the design of the steam turbine show that it can be expected to give an almost perfect adiabatic expansion, as there are no thermal cycles of heating and cooling at every stroke as in the reciprocating engine; there is an almost ideal thermal drop from the steam valve to the condenser. It is also evident that the expansion will be relatively more nearly adiabatic in the low-pressure stage of the turbine than in the low-pressure cylinder of the engine, so that it has been proposed that the reciprocating engine should be run high pressure where relatively it is more efficient than the steam turbine, utilizing the turbine for the low-pressure part of the cycle. In other words, use each where it is most efficient.

The turbo unit would be interposed directly between the exhaust nozzle of the reciprocating engine and the condenser, and would have no valves or governing mechanism whatever. The generator would be connected directly to the other gen-

erator leads without any switching apparatus, except possibly knife switches to disconnect for testing purposes; and in operation no attention whatever would be required beyond the ordinary lubrication of bearings. Such a unit it is evident could be built at a very small cost per kilowatt-hour.

THE INTERNAL COMBUSTION OR GAS ENGINE

The gas engine has probably developed more slowly than any other piece of modern apparatus, as it is now thirty years since the Otto gas engine was introduced. It is only within the last ten years that the larger type of engine, from 500 to 2000 H. P. in size, has appeared. The delay in bringing forward the most efficient motive power known is chiefly due to the difficulty experienced in developing an efficient and inexpensive method of making gas. As far as the production of gas from anthracite and non-caking bituminous coals is concerned, this problem has apparently been solved, but it is still in a more or less unsolved condition for the richer bituminous and semi-bituminous caking coals of the Eastern States.

The following heat balance is believed to represent the best results obtained in Europe and the United States up to date in the formation and utilization of producer gas:—

ANALYSIS OF THE AVERAGE LOSSES IN THE CONVERSION OF ONE POUND OF COAL CONTAINING 12,500 B. T. U. INTO ELECTRICITY

	B. T. U.	Per Cent.
1. Loss in gas producer and auxiliaries	2,500	20.
2. Loss in cooling water in jackets	2,375	19.
3. Loss in exhaust gases	3,750	30.
4. Loss in engine friction	813	6.5
5. Loss in electric generator	62	0.5
6. Total losses	9,500	76.0
7. Converted into electrical energy	3,000	24.0
	12,500	100.0

The great objection to the use of the gas engine for electrical purposes has been,—first, its lack of uniform angular velocity; second, its uncertainty in action and high cost of maintenance; and third, its inability to carry heavy overloads. Recent developments have removed the first and second objections; and a period of vigorous development has resulted in placing the gas engine in the front rank of claimants for attention as a prime mover.

The total investment for a gas-producer plant, all auxiliaries, gas engines, and electric generators, has been reduced by the elimination of the gas-holding tank to a point where it is now practically on a par with a first-class steam plant using high-grade reciprocating engines.

Where natural gas or blast-furnace gas can be obtained the gas engine has outdistanced all competitors; and now that some of our large manufacturers have taken up in earnest the problem of designing producer-gas plants, it is safe to say that rapid developments will result.

The records of operation of several important installations of gas engines in power plants abroad and in this country seem to indicate that only one important objection can be raised to this prime mover, and that is that its range of economical load is practically limited to between 50 per cent. load and full load. This lack of overload capacity is probably a fatal defect for the ordinary power plant, more especially for the average railroad plant operating under a violently fluctuating load, unless protected by a storage battery of comparatively large capacity.

NEW TYPE OF PLANT

Over a year ago, while watching the effect of putting a large steam turbine having a sensitive governor in multiple with reciprocating engine-driven units having sluggish governors, it occurred to the author that here was the solution of the gas engine problem; for the turbine immediately proceeded to act like an ideal storage battery; that is, a storage battery whose potential will not fall at the moment of taking up load, for all the load fluctuations of the plant were taken up by the steam turbine, and the reciprocating units went on carrying almost constant load, whilst the turbine load fluctuated between 0 and 8000 KW. in periods of less than 10 seconds.

The combination of gas engines and steam turbines in a single plant offers possibilities of improved efficiency, whilst at the same time removing the only valid objection to the gas engine.

A steam turbine unit can easily be designed to take care of 100 per cent. overload for a few seconds; and as the load fluctuations in any plant will probably not average more than 25 per cent., with a maximum of 50 per cent. for a few seconds, it would seem that if a plant were designed to operate normally with 50 per cent of its capacity in gas engines and 50 per cent. in steam turbines, any fluctuations of load likely to arise in practice could be taken care of.

We have seen that the thermal losses in the gas engine jacket water amounted to approximately 19 per cent., and as the water is discharged at a temperature above 100 degrees, it can be used to advantage for boiler feed.

The jacket water necessary for an internal combustion engine will probably be about 40 pounds per kilowatt-hour, assuming that the jacket water enters at 50 degrees F.; then the discharge temperature will be

$$50 + \frac{19 \times 12{,}500}{40 \times 100} = 109.4 \text{ degrees F.}$$

As the steam turbine will require only about 15 pounds per kilowatt-hour, including auxiliaries, it is evident that only 37.5 per cent. of this heat or 7.1 per cent. of the jacket water loss can be utilized. The other loss in the exhaust gases of 30 per cent., can be utilized either in economizers or directly in boilers or superheaters.

Thus by utilizing the waste heat in the gas engines for the purpose of assisting to make steam for the turbines, there can be saved approximately 37 per cent. of the total heat lost in the gas engine.

In the summary of analysis of heat balance it was shown that one can reasonably expect to bring the reciprocating engine plant up to a maximum total thermal efficiency of 14.44 per cent., or possibly with steam turbines using superheat, to 15 per cent.

Referring now to Table I. it will be noted that in item 2 the loss in ashes was 2.4 per cent., and the loss to stack in item 3 was 22.7 per cent.; now with the hot gases from the gas engine exhaust it is evident that the loss in 2 will not exist, and that item 3 will be reduced from 22.7 per cent. to about 5 per cent., as the process of combustion is completed in the gas engine. The total efficiency of conversion of this 30 per cent. of heat from the waste gases when used in the turbine plant would then be $15.0 + 2.4 + (22.7 - 5) = 35.1$ per cent.

The heat recoverable from the jacket water was shown to be 7.1 per cent. of the total heat in the coal, so that there is $30\% + 7.1\% = 37.1\%$ of the original heat in the fuel returned from the gas engine, and this can be converted into electrical energy at an efficiency of 35.1 per cent.

For each kilowatt delivered by the gas-engine plant, 3918 British thermal units will be simultaneously turned over to the steam plant, and this in turn will give 403 watts to the steam plant free of cost.

The steam plant will then have only to furnish 1000 — 403, or 597

watts per kilowatt at a thermal efficiency of 15 per cent.; in other words, the economy of the steam part of the plant will be raised to

$$\frac{15}{0.597} = 25 \text{ per cent.}$$

The average total thermal efficiency of such a combination plant would then be

$$\frac{24 + 25}{2} = 24.5 \text{ per cent.}$$

In Table II. will be found a tabulation of the relative values of the

TABLE II.—DISTRIBUTION OF MAINTENANCE AND OPERATION. CHARGES PER KILOWATT-HOUR

Maintenance	Reciprocating Engines	Steam Turbines	Reciprocating Engines and Steam Turbines	Gas-Engine Plant	Gas Engines and Steam Turbines
1. Engine room, mechanical	2.57	0.51	1.54	2.57	1.54
2. Boiler room or producer room	4.61	4.30	3.52	1.15	1.95
3. Coal and ash-handling apparatus	0.58	0.54	0.44	0.29	0.29
4. Electrical apparatus	1.12	1.12	1.12	1.12	1.12
Operation		2			
5. Coal and ash-handling labour	2.26	2.11	1.74	1.13	1.13
6. Removal of ashes	1.06	0.94	0.80	0.53	0.53
7. Dock rental	0.74	0.74	0.74	0.74	0.74
8. Boiler-room labour	7.15	6.68	5.46	1.79	3.03
9. Boiler-room oil, waste, etc	0.17	0.17	0.17	0.17	0.17
10. Coal	61.30	57.30	46.87	26.31	25.77
11. Water	7.14	0.71	5.46	3.57	2.14
12. Engine-room, mechanical labour	6.71	1.35	4.03	6.71	4.03
13. Lubrication	1.77	0.35	1.01	1.77	1.06
14. Waste, etc.	0.30	0.30	0.30	0.30	0.30
15. Electrical labour	2.52	2.52	2.52	2.52	2.52
Relative cost of maintenance and operation.	100.00	79.64	75.72	50.67	46.32
Relative investment, in per cent	100.00	82.50	77.00	100.00	91.20

various items necessary in the maintenance and operation of a power plant. The first column covers a plant with compound condensing reciprocating engines without superheat, and is derived from a year's record of actual costs of a large plant operating with a load factor of approximately 50 per cent., load factor in this case being defined as

$$\frac{\text{Actual output}}{\text{Maximum hour's load} \times 24}$$

The values in the other columns have in the main been estimated from the first column, but wherever possible actual data derived from various sources, both domestic and foreign, have been used; but in all cases all values have been reduced so as to make them directly comparable with the first column, and with one another. The values in maintenance and operation of steam turbines are derived from actual costs.

SUMMARY

1. The present type of steam-power plant can be improved in efficiency about 25 per cent. by the use of more scientific methods in the boiler room, by the use of superheat, and by running the present types of reciprocating engines high pressure, and adding a steam turbine in the exhaust between the engine and the condenser. At the same time the output of the plant can be increased to double its present capacity at a comparatively small cost for turbines and boilers.

2. The steam-turbine plant has an inherent economy 20 per cent. better than the best type of reciprocating-engine plant, not so much due to its higher efficiency as to a variety of causes shown in Table II.

3. An internal combustion-engine plant in combination with a steam-turbine plant offers the most attractive proposition for efficiency and reliability to-day, with the possibility of producing the kilowatt-hour for less than one-half its present cost.

DISCUSSION

E. W. Rice, Jr., of the General Electric Company, in opening the discussion, said in part that he thought Mr. Stott had handled a very difficult subject with unusual ability. The paper showed how the efficiency and economy of a modern reciprocating engine plant can be greatly improved and increased by the addition of steam turbines. In the analysis of the losses which take place in the conversion of a pound of coal in a steam electrical plant, Mr. Stott had applied the method which had been so successful in improving the efficiency of electrical apparatus. Twenty years ago, efficiencies of 75 or 80 per cent. were considered entirely satisfactory for electrical generators. By careful attention to core losses, iron losses, bearing losses and other details, the standard efficiency is now 95 or 98½ per cent. for the larger units. In accomplishing this result the electrical engineer has been greatly aided by the ammeter, voltmeter, and wattmeter. If the steam engineer had the equivalent of these instruments the efficiency of the steam engine plant would, doubtless, have been greatly increased at the present time.

As to electrically driven auxiliaries, no doubt there is much to be said in their favour from the standpoint of convenience, simplicity, reliability and avoidance of unnecessary steam pipes; but they cannot compare in heat efficiency with steam-driven auxiliaries. The inability of eliminating the enormous losses, about 60 per cent. of heat units, rejected to the condenser, emphasizes the importance of working with the highest possible vacuum. Before the introduction of the steam turbine there was no demand for a vacuum greater than 26 inches. The steam turbine, however, is so admirably adapted to working over the lower ranges of pressure that a demand arose for the use of higher vacuum, and it is now common to find vacua of 28½ to 29 inches employed, the barometer being assumed at 30.

In view of the higher efficiency of the steam turbine as compared with a reciprocating engine in the lower ranges of pressure, it will be found profitable to employ a steam turbine for even a smaller range of pressure than between the atmosphere and 28½ inches; in other words, a steam turbine may be inserted in the exhaust between the low-pressure cylinder and the condenser in almost any reciprocating engine plant. Mr. Rice did not think that the advantages to be gained by such a combination would be sufficient to warrant its use in laying out a new station, but it is a most excellent means of increasing the economy, and particularly to add to the output of existing reciprocating engine stations.

The author's suggestion relative to a new type of plant combining the benefits of the gas engine with the well-known efficiency and overload capacity of the steam turbine, was certainly a very interesting and bold suggestion. The gain in total efficiency was so remarkable as to warrant careful and respectful consideration.

Considering the relative investment of a reciprocating engine plant, whether gas or steam, but particularly the steam type, as compared with the rotary engine or the steam turbine type, Mr. Rice thought it was not reasonable to expect any material reduction in the price of reciprocating units in the future. The steam turbine is, however, of comparatively recent date, and looking forward five or ten years it is reasonable to expect that improvements in methods of design or manufacture will result in a very material reduction in cost.

The central station designer must in the future, even more than in the past, give due weight to those most important considerations,—simplicity and reliability. The plant must have the highest practicable degree of working efficiency, but it must above

all things be reliable. Mr. Rice thought the steam turbine will outdistance all its rivals in simplicity and reliability. He would like to see the units reduced to the fewest practicable number, not only the generating units, but the boilers, auxiliaries, steam pipes, switchboard appliances, etc. The safety devices in instruments should be as simple and few in number and variety as is consistent with entirely reliable operation of the station.

Prof. Charles E. Lucke, of Columbia University, said that the development of the gas engine had suffered as much from the manufacturers as from the prejudiced and ignorant persons that handled these engines. The manufacturers have claimed so much for gas engines as regards simplicity and economy of operation that the purchasers of the engines have been inevitably disappointed. There is no machine in existence that can do everything. Each class of machine has its place, and the problem is to find that place, not to condemn any one class. The main conclusion in Mr. Stott's paper is that for economy of power generation in cost per kilowatt-hour, including manufactured cost, together with interest and other establishment charges, the gas engine plant offers in an electric generating station much greater economy, nearly twice as much, in fact, as the reciprocating steam engine plant, and that, with the combination of a turbo-generator with a gas engine generator, there are still greater economical advantages.

If, as proved by Mr. Stott, power costs by gas are less for the highly refined station, and if, as is the fact, the gas engine station does not fall off in efficiency and does not rise in power cost as its size decreases, then it must follow that the small gas engine plant for electric generation will have a higher relative value than the large one, compared with steam.

As to the question of overload capacity, Prof. Lucke stated that the gas engine has a maximum load proportional to its piston displacement, and so has the steam engine. The steam engine is ordinarily operated at a load less than its maximum, and is therefore said to have an overload capacity. The gas engine is said to have no overload capacity because it is intended normally to operate at nearly its maximum load. If a gas engine plant were to be handled as the steam plant is, there would be considerable difficulty about handling the load from this lack of overload capacity, but there is another way out for the gas engine, that is, the cutting in and out of spare units on short notice. Prof. Lucke had repeatedly seen seven 2000-H. P. units put on a load in 3½ minutes. There is no cylinder condensation to worry any one. It is necessary only to pull the handle for the compressed air, twirl the water valve, open the gas valve, and the load can be carried. Synchronism can be secured by the usual methods. This fact offers a valuable suggestion as a counter argument to the lack of overload capacity. This method of handling the gas plant will not, however, take care of momentary wide fluctuations. That can be done only by some other method. The best method within the knowledge of the speaker is that suggested for this purpose by Mr. Stott.

C. C. Chappelle, of Denver, thought that possibly one of the things that would be interesting to state in connection with Mr. Stott's compilation of the relative economies of the reciprocating and steam turbine plants, is the fact that certain data from a large railway station in the East which is equipped exclusively with steam turbines, and which is operated under practically the same conditions of cost of fuel and labor as the large stations in New York, show results that check up within a fraction of a per cent. of Mr. Stott's compilation.

W. L. R. Emmett, of the General Electric Company, said that one of the great things which Mr. Stott's paper makes clear is the very great saving in investment incident to the use of steam turbines. What a man pays for when he equips a steam plant is capacity to carry the peak load. The reciprocating steam engine, particularly in the case of large units, is undesirable from this standpoint, for the reason that the problem in building very large steam engines is to take care of the great weights involved in the low-pressure cylinders and valves. Hence such engines have a tendency to be uneconomical at overload because the temptation presented to the engine builder is to make the low-pressure cylinder small in order to get good economy at certain loads, and get barely through without mechanical difficulties. With the steam turbine, on the other hand, one can get for the same amount of money from 20 to 25 per cent. more maximum capacity.

As to the introduction of low-pressure turbines with reciprocating engines, Mr. Emmett remarked that the latter exhaust at some pressure from the atmosphere up. The steam passes from the engine into a turbine, which is a simple device without governor or any other auxiliaries that tend to introduce difficulties. The steam passes through into the condenser. Now, that turbine performs exactly the functions of a vast third cylinder on that engine, of an adjustable shape and size suited to the load which it receives without cylinder condensation and with all the ideal characteristics that could be desired in a cylinder. It is just another expansion working in the field which the reciprocating engine is incapable of filling. In that field the turbine can give as good economy as in any other field, and that economy closely approximates the actual steam economy producible from a steam engine cylinder.

One of the important things in turbines is obviously the use of high vacuum. There is practically no air leakage and high vacuum is not expensive to maintain. Another interesting matter is that while reciprocating engines can sometimes be run economically non-condensing, the advantage of condensation is so much greater in the turbine that there can be no reason for running non-condensing where turbines are used.

A SELF-EXCITING ALTERNATOR

E. F. Alexanderson then read his paper entitled as above. This described in the main a type of self-exciting alternator developed by the author, but in the course of the description the work of other inventors was also briefly referred to. The paper was discussed by Professor A. E. Kennelly, C. F. Stott, W. L. R. Emmett and several others.

According to "The Iron Age," very fine iron sand found in New Zealand and heretofore useless on account of the difficulty in smelting it is now successfully used by a new process. The sand mixed with carbon is passed through an electric furnace so as to fall in a shower in a zigzag path through a number of carbon grids heated electrically. It is thus melted and reduced and caught in a suitable receptacle below. The charge is met in its downward path by reducing gases. The whole furnace is sealed against the air for the protection of the grids, which are horizontal and built into a framing, also of graphite. The twelve grids are connected in parallel and supplied with current at a pressure of 18 volts. On a consumption of 100 KW. the furnace is said to be capable of taking care of 280 tons of the iron sand per annum.

Artificial Illumination.—IX

By DR. EDWIN JAMES HOUSTON

FIG. I.—ENCLOSED ARC LAMPS IN A DRYGOODS STORE

ILLUMINATION OF DEPARTMENT STORES

FOR the proper illumination of interiors, such as department stores, especially where goods of practically all kinds are exposed for sale, the character of the lighting, as regards its intensity, the uniformity of its distribution, and its daylight values will necessarily vary, not only with the general character of the goods that are to be lighted, but also with the dimensions of the rooms in which the goods are displayed. This is especially so as regards the character of the surfaces of the goods, and their ability either for absorbing or for irregularly reflecting or diffusing the light that is thrown on them.

As regards their general character, there will be found in every large department store many classes of goods that can be properly displayed by almost any kind of light, no matter what its source may be, provided only that the light be supplied in sufficient amount and intensity to permit the general character of the goods to be properly examined. For example, for ordinary housekeeping articles, hardware, garden tools, and articles of similar description, provided a sufficient amount of light is supplied to permit the goods to be clearly seen, it is, comparatively speaking, a matter of indifference whether the light employed contain exact daylight values or not. To a certain extent it is even a matter of indifference whether a perfectly uniform distribution of the light be ensured, provided, of course, the irregularities of illumination are not too distinctly marked. It is sufficient if the goods can be seen with sufficient clearness to permit the detection of defects in their manufacture, or to permit the ready detection of the presence in them of imperfect materials.

For the proper illumination of furniture, ordinary clocks, boots and shoes, stationery, uncoloured chinaware or stoneware, cutlery, and the like, there should, in addition to the proper amount of light, be ensured a fairly good uniformity in its distribution. Otherwise, a proper examination of the goods will be impracticable.

When we come to the illumination of such articles as books and printed matter generally, especial care must be taken to ensure as great uniformity of illumination as possible. Here, however, as regards the amount or the intensity of the illumination, as serious a mistake can be made by providing too great an amount of light, as would result from providing too feeble a light, since the prime requisite of the illumination is to permit a careful examination of the clearness of the type or printed matter, the clearness of the illustrations,

FIG. 2.—A FURNITURE STORE LIGHTED BY GENERAL ELECTRIC ENCLOSED ARC LAMPS

FIGS. 3 AND 4.—SHOWING, RESPECTIVELY, THE ILLUMINATION OF A JEWELRY STORE AND A CARPET STORE

the quality of the paper and binding. For such purposes, too bright a light is even more objectionable, within certain limits, than too feeble a light.

In a similar manner, for the proper illumination of woven fabrics, such as cloths, cottons, linens, silks, velvets, curtains, laces and upholstery generally, the requirements are the same, i. e., a proper amount of illumination to ensure the most distinct vision, and, at the same time, a uniformity in the distribution of the illumination. Without both of these, it would be impossible properly to examine the texture of the fabrics, so as to discover any lack of uniformity in the warp and weft of the woven goods, or to ascertain whether the goods have been so woven as to ensure a uniformity in the distribution of the warp and weft. Moreover, both of these requirements, as regards the light, are necessary to be able to determine the character of the cloth, its texture, and the quality of the materials of which it is made.

There are, however, a large class of goods exposed for sale in practically all department stores in which the question of colour plays the most important part. For the proper illumination of this class of goods, to the sufficiency of the illumination and its uniform distribution there must be added the great essential of the daylight colour values in the artificial light employed. Goods of this character are to be found in all coloured materials, in such as dress goods, silks, satins, plushes and velvets, in zephyrs and worsteds, in sewing silks, in ribbons, carpets, curtains, draperies and upholstered goods generally, in hats, bonnets, plumes, artificial flowers and millinery generally. Since the beauty of these depends so much on their colour values, in many cases being dependent entirely on the presence of certain delicate shades, it is absolutely necessary for their proper illumination that the colour values of the artificial light shall approach as nearly as possible to those of daylight, provided of course the articles are to be worn in the streets or during their exposure to daylight.

There is a class of goods offered for sale in large department stores which, to a certain extent, may be regarded as standing separate and apart from all others, and which, generally speaking, require for their proper illumination the three requisites of sufficiency of illumination, uniformity of distribution, and sufficient approach to the daylight colour values of the artificial light. These, which may be generally classed as articles of luxury, include jewelry, fine watches and clocks, paintings, cut glass, diamonds and precious gems generally. As they are high-priced articles, the prospective purchaser naturally desires to obtain as full an opportunity for carefully and thoroughly examining them as possible.

FIG. 5.—A CLOTHING STORE LIGHTED BY GENERAL ELECTRIC SUSPENDED ARC LAMPS AND INCANDESCENT LAMPS AT THE SIDES

There are so many comparatively obscure considerations that may enter into the question of the proper illumination of high-priced articles of the character mentioned that some of these may naturally escape attention. For example, it might be thought on first consideration that such articles as fine cut-glass ware would not need for their proper illumination any more than sufficiency and uniformity of illumination. When, however, it is remembered that what the eye of a connoisseur is accustomed to find in these goods, is that display of the prismatic colours obtained by the prismatic groovings in the glass, that

can only be obtained to their full extent by the use of light that is absolutely the same as daylight. Such articles, therefore, if illumined by an artificial light that is markedly deficient in daylight values, must fail to produce the best effects from an æsthetic standpoint.

In a similar manner, in the case of the illumination of precious stones, such as diamonds and other almost colourless gems, and even, to a certain extent, deeply coloured gems, marked colour contrasts that require for the production of the best results tints and shades of colour that must be rigorously preserved. For the examination of such goods the artificial light must possess true daylight colour values.

It not infrequently happens that articles of millinery produce very satisfactory colour contracts when examined by the light of the department store. This is due to the fact that such light contains a greater examine the articles not only by artificial light, but by that particular character of artificial light to which they are intended to be exposed while being worn. If, for example, the ball room, theatre or assembly is illumined by an incandescent light, then goods should be examined by an incandescent light, and, moreover, since incandescent lights vary greatly in their colour values, the incandescent light employed for this purpose should be, wherever possible, of the

FIG. 6.—A STORE LIGHTED BY ARC LAMPS WITH DEFLECTING SHADES

the presence of proper daylight values in the artificial light is necessary in order to ensure that play of colours which so eminently characterizes the diamond, and, under certain conditions, even transparent, coloured gems.

Another class of coloured goods that, perhaps, more than any other, suffer from illumination with light in which the daylight values are absent, is found in millinery goods generally. Articles of this character are almost invariably worn in the daylight. As is well known, the value of such articles, so far as beauty of dress is concerned, is absolutely dependent on the nice gradations of colour tints, as well, to a certain extent, as on those more proportion of certain tints and colours than ordinary daylight. When such articles are exposed to daylight, they are quite unsatisfactory either because such colours are missing, or certain objectionable colours are present. The only way to prevent disappointments of this character is to insist on the examination of the goods by light containing daylight colour values only, or what is still better, to examine the general effects by pure daylight illumination.

When, however, as has already been pointed out in a previous article in this series, coloured fabrics or articles of millinery are intended to be worn at night, an examination by daylight colour values would be unsatisfactory, it being necessary to same character as that to which they are to be exposed, i. e., ordinary incandescent lamps, meridian lamps, arc bursts, Nernst lamps, and the like.

Coming to the peculiarities of artificial illumination as determined by the dimension of the rooms in which the goods are displayed, it may be remarked generally that this affects only the amount and the uniformity of the distribution of the light. In other words, the dimensions of a room affect only the amount and distribution of the light, the extent of the daylight values being determined as explained above by the general character and colour of the goods.

There are, generally speaking, two

ways in which the dimensions of a room influence the amount and uniformity of the light required for the proper illumination of goods displayed in the room as follows:—

1. When the dimensions of the room are comparatively great, the space near the walls will naturally be more brilliantly illumined than the space near the central portions of the room.

2. When the rooms are high, the amount of light thrown downwards on the floor will be smaller than when the ceilings are comparatively low.

Assuming that care has been taken in the colouration and the character of the covering of the walls of large rooms, so that a maximum quantity of light will be thrown off and a minimum quantity of light absorbed. If the lamps are suspended from the ceilings only, no lamps being placed on or near the walls, unless a greater percentage of lamps has been placed in the central part of the ceiling, the illumination will necessarily be uneven, since the parts of the room near the walls will receive a greater amount of light than the remaining ones, on account of the light that is diffused or irregularly reflected from the walls.

It sometimes happens, however, especially in the case of large department stores, that much of the wall spaces are occupied by showcases, or shelves filled with goods, in which case so much light may be absorbed by the goods that it will be necessary to place a number of lamps near the cases to ensure uniformity in the distribution. An excellent arrangement for such purposes consists in horizontal lines of incandescent lamps placed near the tops of the cases, or, where the character of the showcase will so permit, of incandescent lamps placed at the top of the case and shielded from direct view from the outside of the case, under these circumstances producing an illumination similar to that of shop windows, before referred to.

When, as is generally the case in the large rooms of department stores, the room contains a number of pillars or columns that are necessary for the support of the ceiling, the spacing of the lamps must be of such a character as to avoid the production of shadows. This can readily be done by properly spacing the lamps. In such cases very satisfactory effects can be obtained by a combination of arc and incandescent lamps. The arc lamps are suspended from the ceilings and clusters of incandescent lamps are placed in suitable bands or circles around some upper portion of the columns at not too great a distance from the surface of the counters or show tables.

It is by no means an easy matter to ensure the greatest amount of light directly on the goods that are to be examined, it is usual to suspend the arc lamps so as to bring the light of

FIG. 7.—DISPLAY OF IMPORTED GOWNS AT JOHN WANAMAKER'S STORE, PHILADELPHIA, PA., SHOWING THE DAYLIGHT EFFECT OF ILLUMINATION BY LIGHT-BALANCING, SELECTIVE-DIFFUSER CEILINGS

properly to illumine large rooms in department stores where the ceilings are high, unless a much greater the arc about 10 feet above the floor, or about $7\frac{1}{2}$ feet from the surface of the tables or counters on which the

FIG. 8.—THE RECEPTION ROOM OF A MILLINERY STORE ILLUMINATED BY LIGHT-BALANCING, SELECTIVE-DIFFUSER CEILINGS. THE FURNISHINGS OF THE ROOM APPEAR TO AS GOOD ADVANTAGE AS THOUGH ILLUMINATED BY BROAD DAYLIGHT

amount of light than usual is employed for their illumination. When the light is obtained by arc lamps suspended from the ceiling, in order goods are displayed. By the use of enclosed arc lamps, suspended from the ceilings of a room of ordinary height and placed 22 feet between

centers, a fairly good and uniform illumination on the tables or counters is ensured. When, however, the ceilings are quite high, the illumination on them will be of a decidedly marked or spotted character, with irregularities consisting of bright and dark spaces that produce a very unpleasing effect in the lighting of this portion of the room.

Although the lack of uniform illumination ensured for the ceilings of rooms of the above character and under the circumstances referred to, does not injuriously influence the illumination of the goods that are and examine generally the goods on either side of them. Judged from this standpoint, any illumination which is limited to the surfaces of the counters must be regarded as insufficient, and, therefore, as unsatisfactory. It will probably require a more extended education on the part of the proprietors of department stores before they will fully recognize the great advantages to be derived from an illumination of the general character here referred to.

By far the more difficult problem to be solved as regards the proper illumination of department stores is light is installed for the proper illumination of the black goods, the white goods will receive a dazzling, glaring illumination that will prevent them from being properly seen. On the other hand, if the light is limited in amount to that capable of properly illumining the white goods, the illumination of the dark or black goods will be insufficient.

There are three ways in which this difficulty can be overcome, namely:—

1. By employing unequal distribution of the lamps, or, in other words, by placing the greater number of illuminating units directly over the

FIG. 9.—A NIGHT VIEW OF A MILLINERY STORE LIGHTED BY GENERAL ELECTRIC LIGHT-BALANCING, SELECTIVE-DIFFUSER CEILINGS

under immediate examination on the counters, yet there is thus produced a decided lack of those general æsthetic conditions that should, as far as possible, be maintained in all parts of large department stores. The modern department store is properly to be regarded as a species of everyday exposition or exhibition of all manufactured articles of a character apt to be required by the general public. Every effort is made to induce the public to visit such stores as exhibition marts, without any immediate purchases being made.

It follows, therefore, that while the illumination of department stores should be of a character to ensure the best illumination on the counters where the goods are actually inspected for sale, yet the general illumination should permit a fairly thorough examination of the goods from a distance, i. e., by the people as they walk through the aisles of the stores that which is necessitated by the character of the surfaces of the goods for absorbing or throwing off the light falling on them. There are many classes of goods in department stores, especially in the tailoring department, that both by the character of the surface, as well as by the colour, cause by far the greater portion of the light they receive to be absorbed. This is found in the case of most black cloths for tailoring, or of dark-coloured fabrics generally.

Such materials require for their proper illumination a far greater amount of light than is necessary for the illumination of white goods. If, therefore, the plan generally employed for lighting department stores is followed, and a uniform space is maintained between consecutive lamps independently of the character of the goods that are to be illumined, very unsatisfactory effects must necessarily result. If a sufficient amount of counters where the dark-coloured goods are to be displayed.

2. By placing the dark-coloured goods in portions of the room, or in separate rooms by themselves, and supplying them with the proper amount of light.

3. By placing the dark-coloured goods on a white or light-coloured background, this resulting in their receiving a proper side illumination from secondary radiation of light.

Perhaps, in most cases, the best results can be obtained by the combination of the three methods.

The artificial sources of light employed at the present time for the illumination of department stores, consist principally of enclosed arc lamps and various forms of incandescent electric lamps. A third form of light that was lately introduced consists of an improved form of incandescent mantle gaslight in which the mixture of gas and air is heated before igni-

tion. Where such lights can be so placed as to avoid fire risks arising from the inflammable nature of the materials to be found in all department stores, they are capable of producing very satisfactory results.

In practically all installations for internal illumination, only enclosed arc lamps are now employed, the old form of open-arc lamp having become almost obsolete. For interior lighting, such as department stores, the enclosed-arc lamp is employed alone or in connection with devices known as concentric diffusers, or with light-balancing, selective-diffuser ceilings, or the enclosed-arc lamps are employed alone, merely suspended from the ceiling of the room, or in some cases these lamps are placed under suitable reflectors or shades.

Incandescent electric lamps are employed by placing them under reflectors or shades, or by placing them inside of glass globes that are sufficiently frosted or ground to obtain a diffused light from the entire area of the globe, or they are placed inside of opal globes. In all such cases, the advantage is ensured of greatly increasing the area of illuminated surface from which the light is diffused in all directions.

In some cases, clusters of incandescent electric lamps are grouped together in what is known as an "arc burst." A light of this character is capable of producing very pleasing effects for the lighting of comparatively small spaces. Where they are employed in sufficiently great numbers, however, they may be advantageously used for the lighting of large areas.

The Nernst lamp also is capable of being advantageously employed for the lighting of the interiors of department stores and other similar places. This lamp possesses the advantage of producing a light that is intermediate in its intensity between the arc lamp and the incandescent lamp.

Another form of incandescent lamp, which is employed to a considerable extent in the lighting of department stores, is known as the meridian lamp. It also, like the Nernst lamp, as regards the intensity of its illumination, occupies a place intermediate between the arc and the incandescent lamp.

In order to show the manner in which each of these different classes of illuminants are actually employed, it will be well to discuss a number of night photographs that have been taken of interiors artificially illumined in different department and other stores. Taking first the case of enclosed-arc lamps, Fig. 1 shows

FIG. 10.—A CLOTHING STORE ILLUMINATED WITH LIGHT-BALANCING, SELECTIVE-DIFFUSER CEILINGS

the application of this type to a drygoods store. Here, as will be seen, a fairly effective illumination is obtained. While, however, the amount of light on the counter and in its neighbourhood is sufficient for the display of white goods, yet there is, to some extent, an insufficiency of light for the proper examination of the dark goods. It will be seen that the contrasts between the illumination of the white and the dark goods is very marked. So far as general appearance is concerned, an advanage would probably be ensured in this case if the dark-coloured goods were collected by themselves in a more generously illumined space. To a certain extent, however, the placing of the dark-coloured goods between white goods results in a better illumination of the latter.

Fig. 2 shows the lighting of a furniture store in Wilmington, Del., by means of 61 General Electric Co's enclosed-arc lamps. Here, as will be seen, the general illumination is quite satisfactory, although a space on the left-hand side of the illustration, midway between the two suspended incandescent lamps, shows in general insufficient lighting. Marked shadows appear on the floor, but these are not objectionable. Al-

FIG. 11.—RECESSED TYPE OF LIGHT-BALANCING, SELECTIVE-DIFFUSER CEILING IN A CLOTHING STORE

though the lamps are placed near the ceiling, yet it will be noticed that the illumination of the latter is characterized by a want of uniformity in distribution, there being marked shadows and light spaces.

FIG. 12.—GENERAL ELECTRIC MERIDIAN LAMPS IN THE DINING ROOM OF THE STEAMER "C. W. MORSE"

Fig. 5 shows the illumination, by means of suspended arc lamps, of a clothing store in New York City. Here, as will be seen, a considerable portion of the goods are dark coloured, resulting in the absorption of a large percentage of the light. The distribution of the light, however, is such that the surfaces of the show tables are fairly well illumined, this illumination being markedly increased by secondary radiation from light-coloured pasteboard boxes filling the shelves shown on the right-hand side of the illustration. In addition, by a combination of incandescent electric lamps placed in horizontal rows along the side walls of the room, a marked advantage has been gained in the uniformity of the illumination. In addition to this, chandeliers are provided with incandescent electric lamps, but these do not appear to have been lighted at the time the photograph was taken.

Fig. 3 shows a similar effective combination of arc and incandescent lamps employed for the illumination of a jewelry store. Here the arc lamps are suspended, as shown, from the ceiling of the room, while the incandescent lamps are placed either on pendants or on metallic bands placed comparatively near the showcases around the columns or pillars of the room. Although, as will be seen from the illustration, comparatively little illumination is received by the floor, yet this is not objectionable, since the surface of the showcases is well illumined, and here is where the light is required.

Fig. 4 shows a less satisfactory illumination of a New York carpet store by suspended arc lamps. In the hanging of these for the display of objects that are placed on the floor of the room, such as carpets, the serious mistake has been made of placing them so far from the floor that the amount of light that falls on them is not as great as could be desired. As will be seen in the illustration, these lamps have apparently been placed at the same distance from the ceiling as is necessary in other portions of the store to ensure a good illumination of objects placed on show tables, for, as shown on the left-hand side of the illustration, the light on the ends of rolls of carpets and on piles of rugs at about this height is very much better than that on the carpets placed on the floor of the showroom.

In Fig. 6 is shown the illumination of a jewelry store by means of arc lamps. Here, however, the presence of the deflecting shade, placed as shown, results in a fairly efficient illumination of showcases containing cheap jewelry.

The use of secondary diffusers and shades, either alone or in combination with a light-balancing, selective-diffuser ceiling, have quite recently come into extensive use for the illumination of department stores. This is owing to the fact that this device ensures a uniformity of illumination that is exceedingly effective. The concentric diffusers are made both with convex and with concave diffusers.

The photograph, of which Fig. 7 is a reproduction, was taken at night in a room in a large Philadelphia department store, where the lighting is obtained by means of light-balancing, selective-diffusers ceilings. The uniformity of the illumination is clearly indicated in the illustration.

Fig. 8 shows a very pleasing effect produced by the combined use of a light-balancing, selective-diffuser

FIG. 13.—MERIDIAN LAMPS IN A MUSIC STORE

ceiling and suitably placed incandescent lamps. This, being a reception room in a millinery store, does not require any special illumination, a general illumination, on the contrary, being desirable. As will be seen, this has been obtained to great advantage, there being no marked shadows except under the chairs and tables, and in the neighbourhood of the cone of the light-balancing, selective-diffuser ceiling.

Fig. 9 is from a night photograph of a millinery store illumined by the light-balancing, selective-diffuser ceiling. Apparently, incandescent lamps are placed inside of the showcases near the top, so as to be shielded from the eye of an observer on the outside of the case, thus ensuring a very pleasing effect similar to that obtained by show-window illumination.

Fig. 10 shows the manner in which the use of arc lamps with light-balancing, selective-diffuser ceilings is made to meet the difficult case of the illumination of a clothing store. Here, by the use of a fairly considerable number of selective-diffuser ceilings, excellent illumination is obtained on the counters, as well as on the floor of the room. In this case, however, a disagreeable lack of uniformity in the illumination of the ceiling is clearly discernible.

While the use of the light-balancing, selective-diffuser ceiling produces, as shown in the foregoing illustration, very excellent results for ensuring uniform distribution of light below the sources of light, yet this method of illumination is objectionable for three reasons, namely:—

1. The downward projection of the light-balancing cove tends to produce shadows on the ceiling.

2. The upward flaring shade of the reflector collects dust, and rapidly decreases the efficiency of the lamp.

3. As the carbons are consumed, the arc assumes a position further down in the enclosing globe, so that the distribution of the light becomes less satisfactory.

By the use of the recessed type of light-balancing, selective-diffuser ceilings in the clothing store shown in Fig. 11, the irregular distribution of light on the ceiling is to a great extent avoided.

Owing to the greater number of luminous sources, very satisfactory effects are produced for the illumination of department stores by the use of incandescent lamps generally. For this purpose meridian lamps are especially suitable, from the fact that the intensity of their light is greater than that of ordinary incandescent lamps. Fig. 13 shows the satisfactory character of the illumination of a music store that is obtained in this manner. Fig. 12 shows an equally satisfactory illumination obtained by meridian lamps in the case of the dining-room of a steamer. In both these cases, the lamps are placed near the ceiling of the room. The Nernst lamp is capable of producing very satisfactory lighting for department stores. This can be seen from an inspection of Fig. 14.

FIG. 14.—A STORE LIGHTED BY NERNST LAMPS MANUFACTURED BY THE NERNST LAMP COMPANY, PITTSBURG

The General Electric Company has recently brought out a greatly improved form of incandescent electric lamp known as the "high-efficiency, high-candle-power" incandescent unit. This lamp is especially suitable for the lighting of such interiors as department stores. The general appearance of the lamp is shown in Fig. 15. The filaments of the lamp are made by a new process, by means of which an efficiency of $2\frac{1}{2}$ watts per candle has been obtained. The bulbs employed are larger than those employed for ordinary lamps. The light produced by these lamps is of high brilliancy, and by the use of a "Prismos" reflecting shade, are capable

FIG. 15.—A NEW HIGH-EFFICIENCY INCANDESCENT LAMP MANUFACTURED BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y. THIS LAMP HAS AN EFFICIENCY OF $2\frac{1}{2}$ WATTS PER CANDLE

of ensuring a very satisfactory uniformity of distribution below the source of light.

The shades employed with this lamp are made in two different

FIGS. 16 AND 17.—SHOWING, RESPECTIVELY, THE "D" AND "C" FORMS OF REFLECTORS USED WITH THE LAMP SHOWN IN FIG. 15

forms, shown in Figs. 16 and 17, respectively. Some idea of the distribution of the light that is ensured by these shades will be seen from an examination of Figs. 18 and 19, which show respectively the curves of candle-power obtained by the use of these reflectors. The form of reflector shown in Fig. 17 is suitable for use in long, narrow rooms with high ceilings, such as hallways and in window lighting, or wherever a downward concentration of the light is required. Fig. 16 shows a form of reflector in which a distribution of

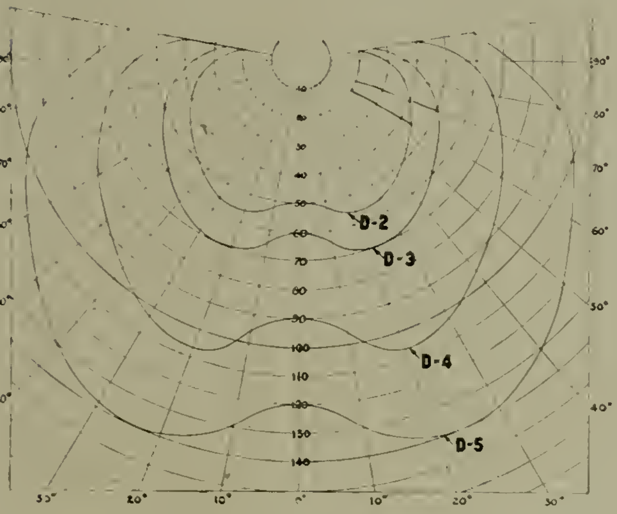


FIG. 18.—CURVES SHOWING DISTRIBUTION OF LIGHT WITH "D" FORM OF REFLECTOR

light is obtained similar to that which results from the use of the well-known meridian lamp and reflector.

Before concluding this article on the illumination of department stores, attention should be called to the fact that unless the apparatus installed for the production of the artificial light required for the illumination of department stores is supplied with the pressure for which it has been designed, the proper results cannot be expected. It is quite a common occurrence, on making an inspection of an electric lighting plant of this, or indeed of any other, description, to find that the pressure supplied to the lamp is far below that at which the manufacturers intended they should be operated. Of course, as is well known, in such cases unsatisfactory results must arise from the decrease in the amount of light, and especially from the decrease in the daylight colour values.

The advantages that are to be derived from the intelligent illumination of department stores so as to ensure the necessary amount and distribution of light possessing the proper daylight values, are well stated in an article that recently appeared in "The Drygoods Economist." This paper is a medium for the presentation of the views of the wholesale and the retail drygoods merchants throughout the United States. Attention is called in the article to the evident fact that the successful illumination of a department store is one of the conditions requisite for its successful retailing of goods. Attention is also called to the fact that in the case of a particular installation of enclosed-arc lamps, each lamp is provided with a separate push-button switch. By this means the advantage is ensured of permitting the independent use of any single lamp, without the necessity for throwing on a current for lighting an entire group of lamps. By such a use of a push-button switch, a man in any department is able to throw on the light just when he wants it. In this manner, where the sales of silk for evening wear are being made, and customers properly insist on seeing the effects of the electric light on them, by the use of the push-button switch this type of illumination can be instantly obtained.

As regards the ability of the enclosed-arc lamp to successfully bring out the peculiarities of certain types of colored goods, the following remarks are made in the paper referred to:—

"Opinions probably differ regarding the diffusion or distribution of light, some merchants believing that a lamp throwing a large percentage of light directly downward on a desired space or article has a more beneficial effect. We take a different view, but only after the most thorough tests. The enclosed-arc lamp, now being used by us all over our store, distributes light successfully, throwing a proper amount on the desired space as well as illuminating a proportionate radius, and diffusing a light equal to daylight.

"We find this particularly useful in our silk departments. Take, for instance, the fine, delicate colourings and tints in the past season's line of foulards. We find that the enclosed-arc lamp brings these out accurately and successfully. For an even surface, such as Peau de Cygne, Peau de Soie, Satin Duchesse or Crepe de Chine, or even plain satins, we find this lamp brings up the tint and not only does not detract, but adds to the brilliancy of their lustre.

"We feel that with a direct downward light of large percentage, the fabric would suffer. This applies also to our window or interior decorations. When trimmed effects are desired, we do not hesitate to drape portieres, or fabrics of the most delicate tints along our shelves or side walls, for the enclosed-arc lamp, distributing its light in the way it does, brings out all the colourings effectively and successfully. Probably a still better illustration would be our carpet department. We find with the lamp we are using in our carpet department, we derive just the desired results and that we are not only able to better please our trade, but are able to bring out the shadings and effects correctly, a condition so necessary to successful carpet selling."

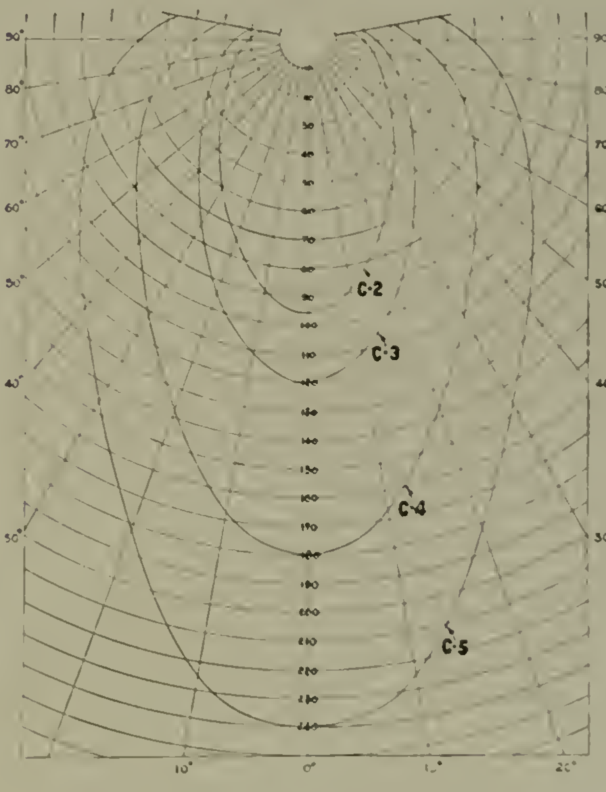


FIG. 19.—CURVES SHOWING DISTRIBUTION OF LIGHT WITH "C" FORM OF REFLECTOR

Electrical and Mechanical Progress

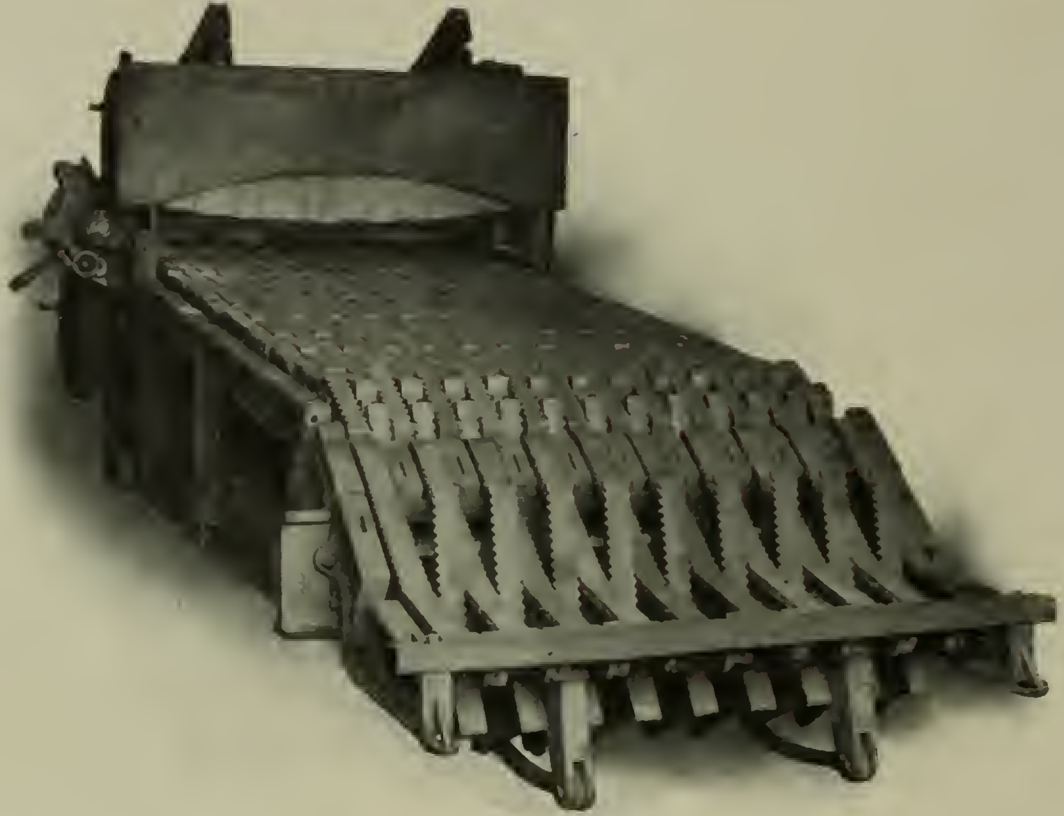
The American Chain-Grate Stoker

THE chain-grate stoker built by the American Stoker Co., of Erie, Pa., and illustrated herewith, consists of a right and a left frame with a fuel hopper, a traveling self-cleaning grate, and the necessary driving mechanism. No part of the stoker is connected with the boiler frame or setting. It is mounted on wheels, which are supported by rails so that the entire machine can be quickly drawn by means of levers under the boiler. The entire stoker is so designed that any part can be easily renewed.

The chain grate is driven by sprocket wheels keyed to the main driving shaft and is pushed into the furnace over rollers by the driving mechanism. At the rear of the frame is the idler shaft, on which the idler wheels run loose. They are covered with sheet iron to form a drum. The grate is an endless chain consisting of a series of narrow links all of the same design, thus simplifying the construction considerably. Between each link is placed a cast-iron roller, the width of which regulates the air space between the links and varies to suit the different grades of coal. Any link can be easily replaced without disturbing other links or removing the stoker.

The driving shaft is mounted in a movable box and is provided with a tension bolt to set the centers of the two shafts perfectly even. Any slack of the chain can be quickly taken up while the stoker is in motion. The driving mechanism is operated from an overhead shaft by a connecting rod attached to a pawl lever with a pawl which drives a ratchet wheel. The ratchet is keyed to the worm shaft, and, through the medium of the worm gear, which is fastened to the sprocket shaft, the chain grate is operated. An adjustment at the ratchet gives the chain four different speeds.

The principle feature, however, of this stoker equipment is the independent attachment at the rear of the grate, between the end of the latter and the bridge wall. It has solved the problem, it is claimed, of burning any kind of coal on a traveling grate. The attachment is comprised of clinker breaking and dumping bars mounted loose on a shaft. These bars are provided with levers and connected by rods to levers mounted on a shaft at the front of the stoker. Each set of bars is operated separately. The long or dumping bars are cast in two pieces, the upper end being made of a hard and durable iron to prevent wear and burning out. They are easily replaced and the cost is very slight.


A CHAIN-GRATE STOKER BUILT BY THE AMERICAN STOKER COMPANY, ERIE, PA.

Heretofore, it has been contended that it was impossible to force boilers with a chain grate without losing in economy. This attachment, it is claimed, makes it possible to force boilers to the limit, as all unconsumed fuel, instead of being thrown into the ash pit, is carried from the grate to the attachment, where it

remains until every heat unit has been utilized. The attachment also permits of a much larger combustion chamber, and exposes a large portion of the boiler to the fire. It also makes it possible to install chain-grate stokers in batteries where boilers are close together.

Cable Construction for Varied Service

NOW that the requirements each year for all classes of electric service demand an increasing amount of underground work, corresponding attention has been paid to the design of the necessary cables. The differentiation carried on along other lines in the electrical field, has been followed in this territory as well, and the results of this selective process are well shown in the cable equipment for the recently electrified Long Island Railroad.

For the interior wiring in the generating station and sub-stations of this railroad, about 19,000 feet of 11,000-volt cable with varnished cambric insulation, braided finish, were installed by the General Electric Co., of Schenectady, N. Y. Fig. 2 shows this cable, all of which was tested by the company with 30,000 volts for 30 minutes after it had been immersed in water for 24 hours, and was again tested with the same potential after installation.

Varnished cambric insulation was selected as the best available insulating material for this use, as it has been demonstrated that cables in-

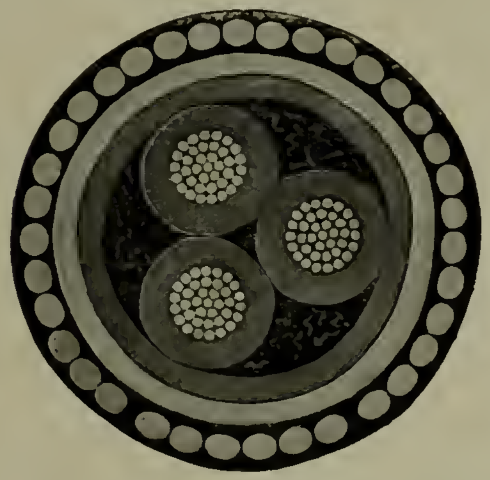


FIG. 1.—SECTION OF A THREE-CONDUCTOR, 250,000-CIRC.-MIL, 11,000-VOLT SUB-MARINE CABLE, MANUFACTURED BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y. LESS THAN TWO-THIRDS ACTUAL SIZE

sulated with this material are better for withstanding high voltage than the best rubber cables, and are not subject to deterioration from static discharges or heat. Furthermore, the fact that these cables could be used without lead sheaths, avoided the installation of a large number of end bells.

Varnished cambric insulation with braided finish was also used for the low-tension wiring in the generating and sub-stations, where in all about 36,000 feet, in sizes from 2,000,000 circular mils down to No. 2, were installed for this work. Several of the reasons governing the selection of varnished cambric insulation for the high-tension work applied with equal force in this case, with the additional advantage that in the large cables the heating of the conductor, due to overloads, could not soften

In connection with the third-rail circuit for jumper cables at grade crossings, and in places where the third rail was shifted from one side to the other of the main track, 65,119 feet of 2,000,000-circular-mil, varnished cambric cable, leaded, with a jute and asphalt finish, were installed. Cables for this service operate under particularly severe conditions, as they are subject to heavy overloads and to deleterious electrolytic action. The overload feature rendered rubber insulation undesirable, while the difficulty of maintaining the lead sheath in good condition

FIG. 2.—A SINGLE-CONDUCTOR, 500,000-CIRC.-MIL, VARNISHED-CAMBRIC AND DOUBLE-BRAIDED CABLE

the insulation and decentralize the conductor.

In the underground part of the transmission circuits, lead-covered, paper-insulated cable is employed. For this purpose about 135,000 feet of three-conductor, 250,000-circular-mil cable, guaranteed for 11,000 volts, were used. This cable was also tested with 30,000 volts for 30 minutes by the manufacturers, and the test was repeated after the cable was installed. The selection of paper cable for this service was determined primarily by the fact that it was considerably cheaper than varnished cambric cable. While there is no question that the varnished cambric cable would be the best for the service, it was felt that satisfactory life and service would be obtained with the paper cables, assuming that proper care was taken to preserve their lead sheaths from deterioration due to electrolysis or corrosion.

For carrying the high-tension circuits under water, where the drawbridges intercept the overhead circuits on the line across Jamaica Bay, 3500 feet of the cable shown in Fig. 1 were used. This is a 250,000-circular-mil, rubber-insulated, leaded and wire-armored submarine cable. As in the previous cases, the cable was tested at 30,000 volts before and after installation. It weighs 18 pounds per foot and is one of the heaviest ever manufactured. The armor is No. 4 B. & S. gauge, and the finished diameter about 3 inches.

proved an equal barrier to the use of paper. The varnished cambric insulation, being free from the weaknesses of both these types of insulation, and yet possessing all the good points of both types, has no rival in this field.

The jute and asphalt jacket was put on these cables to protect the lead from mechanical injury and corrosion, since the cables are in many cases buried directly in the earth.

To carry the third-rail circuits and also the track circuit around the drawbridges at Jamaica Bay, 5600 feet of 2,000,000-circular-mil, rubber-insulated, lead-covered and wire-armored cable were installed. The submerging of these cables maintains them at a low temperature, which tends to preserve rubber and justifies its use in this case.

As a reinforced feeder for the third rail, 9438 feet of paper-insulated, low-tension cable were installed in conduit. This was selected as the cheapest available construction for the service, since the installation was regarded as being of a more or less temporary nature, and because the ultimate life of the cable was not an important feature.

All the cable described, as well as the necessary wire and cable for the cars, was furnished by the General Electric Company. The aggregate length of all kinds of wire and cable supplied for this installation was 637,243 feet, the sizes ranging from No. 12 to 2,000,000 circular mils.

The entire equipment is now in service and giving perfect satisfaction. It is understood that the same company will also supply the high and low-tension cables for the electrification of the New York Central, comprising about 164,000 feet.

These will include a three-conductor, No. 0000 11,000-volt cable, the largest 11,000-volt cable ever made, and a 1,250,000-circular mil, single-conductor cable for track connections, operating at 700 volts. Because of the successful use of these cables, over half a million feet of both high and low-tension cables have been ordered from the company by the New York Edison Company for its requirements in 1906. These range in size from three conductor, 250,000-circular mil, 6600-volt, up to 1,000,000-circular mil, low-tension feeder cable.

A Transformer for Thawing Pipes

A TRANSFORMER built by the Pittsburg Transformer Company, of Pittsburg, Pa., for thawing pipes electrically, is shown in the annexed illustration. It is designed to take a small current from the 1100-volt or 2200-volt line and deliver a heavy current at a suitably low voltage.

The wires *1* run from the line to the primary fuse blocks *2, 2*. The primary leads of the transformer run through porcelain bushings in the backboard and into the fuse blocks. Within the transformer is a porcelain terminal block, changing the connection of which adapts the transformer to operate on circuits of approximately 1100 volts, or those of approximately 2200 volts.

Four secondary leads issue from the front of the case and pass to the terminals of the double-pole, double-throw switch *4*. Throwing this switch to the left *B*, connects the secondary coils in multiple so that the transformer delivers 37½ volts, and has a capacity of about 800 amperes. Throwing the switch to the right *A* puts the secondary coils in series, so that 75 volts and 40 amperes are obtained.

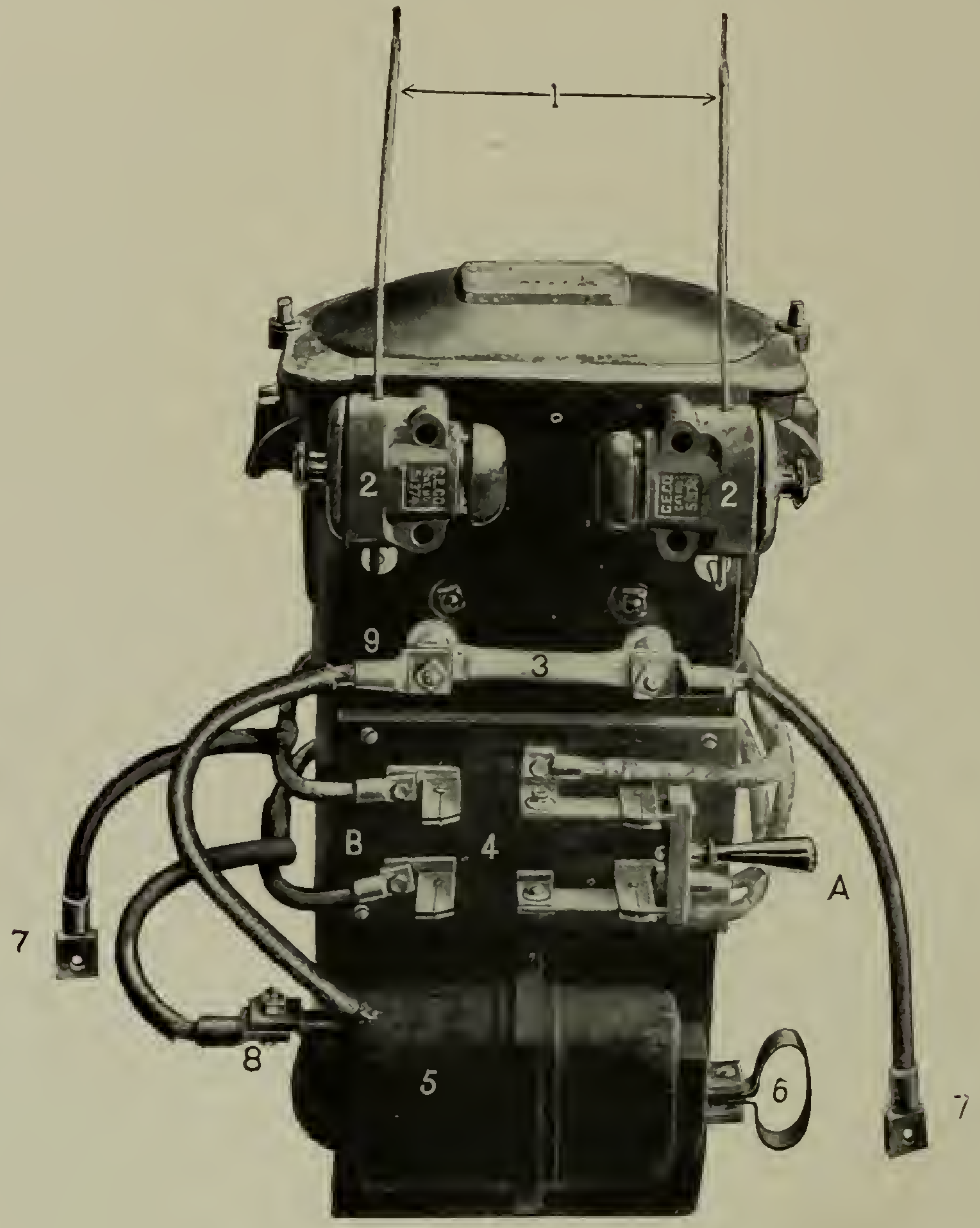
The secondary line passes through the choke coil *5*, and thence through the heat indicator *3*. The terminals *7, 7* are connected to the cables leading to the frozen pipe. The choke-coil plunger is shown at *6*.

The choke coil consists of several turns of copper rod, and has a laminated iron core, supplied with a handle for pushing in and out, thus altering the choking effect to suit the conditions involved. The heat indicator is simply a short section of lead pipe connected in series with the low-voltage winding, in the same manner as a fuse, its temperature being a guide to the heating of the pipe under treatment.

The capacity of the transformer is normally 400 and 800 amperes, but currents considerably in excess of these values may be drawn for short periods. It should be remembered that usually the temperature of the air will be below freezing point or even many degrees below zero. Under such conditions a temperature rise in the transformer as high as 100 to 125 degrees C. above the air will still be within the usual working limits.

The intermittent nature of the work is also favorable, and it will frequently be found that 500 to 600 or 1000 to 1200 amperes can safely be drawn from the transformer. Snow or ice can also be applied to the cast-iron case to assist in cooling when running under extreme loads for considerable periods of time.

It is to be noted that ammeters or voltmeters are valueless for this work, and are therefore a needless expense. The operator has no interest in the voltage or the current strength, so long as these are sufficient for the purpose. The heating effect is the important feature, and it is a simple matter to judge this by touching the heat indicator with the hand or with a wet mitten. The most unskilled operator knows when this pipe is hot, although he might be entirely at a loss to know whether he should use 200 amperes or 500 amperes were he dependent upon an ammeter.



A PIPE-THAWING TRANSFORMER BUILT BY THE PITTSBURG TRANSFORMER COMPANY, OF PITTSBURG, PA.

A New Variable Speed Motor

THE variable-speed motor built by the Lincoln Electric Manufacturing Co., of Cleveland, Ohio, and illustrated on the next page, is unique in its method of obtaining the speed variation. The motor is an ordinary shunt motor, the armature being wound as an ordinary armature in any shunt-wound motor.

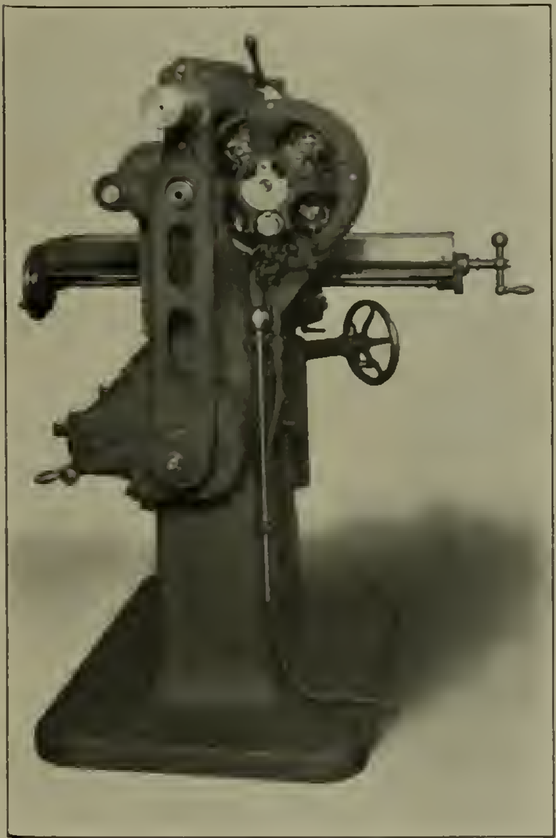
The speed variation is obtained by withdrawing the armature from the

influence of the field poles, thus increasing the magnetic resistance between the field poles and the armature. This decreases the magnetic air gap increases. This would not occur with the cylindrical armature. Thus the increase in the resistance of the air gap is more rapid with a con-

A NEW VARIABLE-SPEED MOTOR BUILT BY THE LINCOLN ELECTRIC MANUFACTURING COMPANY, CLEVELAND, OHIO

flux and thus increases the speed.

It is possible to obtain a more rapid change in speed with a given lateral motion by making the armature slightly conical. When a conical armature is used, its withdrawal decreases the area of the air gap in the same proportion as it would if a cylindrical armature were used, but at the same time the length of the ical armature than with one of a cylindrical type, so that a given variation in speed can be more readily obtained with the former than with the latter.



A MILLING MACHINE DRIVEN BY A LINCOLN VARIABLE-SPEED MOTOR

Special commutating poles are provided, under the influence of which the armature comes as it is withdrawn into its positions of high speed. It is claimed that these poles produce sparkless commutation at all loads from no load to 100 per cent. overload. It is also claimed that wide ranges of speed are possible with this construction, a variation of 10 to 1 being easily obtained, and that a wider variation can be obtained if desired.

A hand wheel is used in connection with a screw mechanism to move the armature laterally, and by means of this hand wheel it is possible to get an infinite variety of the speeds from the lowest to the highest. The magnetic pull of the armature is carried on ball-thrust bearings which eliminate all friction. The brushes are carried on the thrust bearing, and as the latter, the armature and the commutator all move together, there is no relative lateral movement between the commutator and the brushes.

The fields and the armature coils are shaped and treated so as to provide the best ventilation and heat radiation, so that notwithstanding the exceptional small size and weight of the motor, the heating, even at very low speeds, is well within the margin of safety.

Regarding the efficiency, it is claimed that tests of a 5-H. P. motor with a speed range from 300 to 1500 revolutions per minute, gave 75 per cent. efficiency at full load, running at 1700 revolutions per minute, and 87 per cent. at full load, running at 300 revolutions per minute. Had the speed in the first case been normal, 1500, the efficiency would have been higher. It is also claimed that the horse-power is constant throughout the entire range of speed.

A New Magnetic Brake

A NEW magnetic brake manufactured by the Electric Controller & Supply Co., of Cleveland, Ohio, for use with electrically driven machinery of 1 to 100 H. P., is shown in the illustration on the next page.

The friction plates of these brakes are of metal and run in oil, thereby, it is claimed, making the coefficient of friction absolutely constant under all conditions.

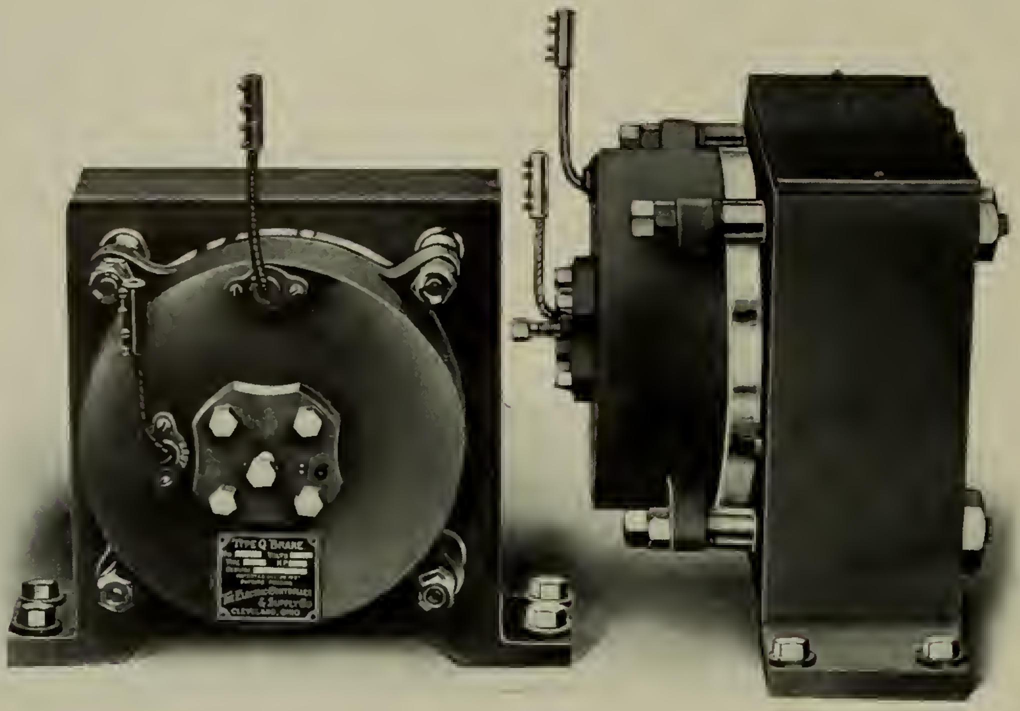
In all cases where electrically driven machinery requires frequent stops and reversals, the facility and speed of handling material, and also the safety of the crane or other machinery employed, depend upon the accuracy and reliability of the brake. The braking force of these brakes is always a definite and constant quantity, is applied axially and is balanced within the frame of the brake, allowing no blow or unbalanced thrust on the bearings of the motor.

The brake is released by an electromagnet through a very small air gap, the magnet operating quickly with a comparatively small current and without any hammer blow. The braking force is always a maximum and is equally effective in either direction of rotation. The heat is carried away from the friction surfaces by the circulation of oil and is effectively radiated from the entire surface of the friction case.

Adjustment of the braking force can easily be made by simply screwing in or out the adjusting screw in the center of the spring cover. When the total amount of wear on all the plates equals ¼ inch, one new square plate can be placed in the friction case by removing the magnet case and two top studs. The brake is designed and always tested to release on ½ full-load current of the motor as a maximum. Owing to the large pole area, the brake does not drop back until about 1-10 full-

load current, insuring a continued release of brake until the current is entirely cut off.

Weather protection is provided for



AN ELECTRO-MAGNETIC BRAKE MANUFACTURED BY THE ELECTRIC CONTROLLER & SUPPLY COMPANY, CLEVELAND, OHIO

by the coil being entirely enclosed, protecting it absolutely from mechanical injury, grounding or short-circuiting. The working parts of the brake are also enclosed in a waterproof case, insuring equally good service under all conditions of weather. All parts are standardized, being machined from jigs, thus permitting interchangeability of parts.

The friction case is a square open box provided with supporting lugs or feet; a cover is provided for the easy inspection of the working parts and a circular opening on the motor side for removing the hub. This case contains the following essential parts:—

Square stationary friction plates, prevented from rotating by studs at four corners of the case, and free to move laterally.

Circular moving plates supported by and keyed to the hub and free to move laterally.

The hub is made of steel with keys cut from the solid, supported by, and firmly keyed to, the motor shaft. It is provided with an oil slinger to throw oil inside the case and prevent it running out at the hub opening. Lubricating oil is placed in the case to a depth of $\frac{1}{2}$ inch below the lowest point of the hub opening. The moving plates, dipping in the oil, throw it by centrifugal force to the top of the case whence it drops on the friction plates, effectually lubricating them. The oil also acts as an agent to carry the heat away from the friction plates and distribute it over the entire surface of the case.

The electromagnet is mounted on the studs which prevent the stationary plates from revolving. The coil of this magnet is form wound, thoroughly insulated and treated with a vacuum and drying impregnating process which practically converts the copper and insulation into a solid mass, thus excluding all moisture from the coil and aiding in the dissipation of the heat. The brake is designed in three forms to meet the service demanded in different classes of electrically driven machinery.

Dust-Proof Metal Lockers

SUPPLEMENTARY to the description in the December issue of THE ELECTRICAL AGE of the expanded metal lockers manufactured by the Edward Darby & Sons Co., Inc., of Philadelphia, Pa., may be mentioned a dust-proof locker, illustrated herewith.

From time immemorial it has been the custom to use lockers, boxes, cases, and the like, for storing clothes, materials, documents and papers. These have been made from different materials, but mainly of wood, and have been dirty, poorly constructed and quickly consumed in case of fire. Within the past three years metal office furniture and fixtures have proved their worth so strongly that to-day there is scarcely a firm or corporation that considers its office or factory up to date, unless its equipment, such as lockers, filing cabinets, cases, and tables, is made of sheet steel.

There are many reasons for this. In comparison with wood as material for such furniture, steel possesses every advantage. Its use simply means greater convenience and economy. It enforces more system and saves employees' time. It encourages neatness and cleanliness, prevents waste and gives increased protection against fire.

To corporations employing a large number of men one of the main requisites is clothes lockers, and where space is valuable the installation of this important equipment is a matter of much thought. When installed in a place where dust is prevalent, a locker of the type illustrated is used. Ordinarily, however, the expanded metal locker is installed.

The value of the expanded metal locker as a clothes receptacle is generally recognized, especially by manufacturers. Being made entirely of open mesh, they allow a free circulation of air, and are in consequence well ventilated and sanitary. Moreover, the contents of each individual locker can be thoroughly inspected at any time. They can be easily fumigated without the articles in the locker being removed. They are germproof, fireproof, and are time-savers.

A complete line of metal furnish-

A DUST-PROOF LOCKER MANUFACTURED BY THE EDWARD DARBY & SONS COMPANY, INC., PHILADELPHIA

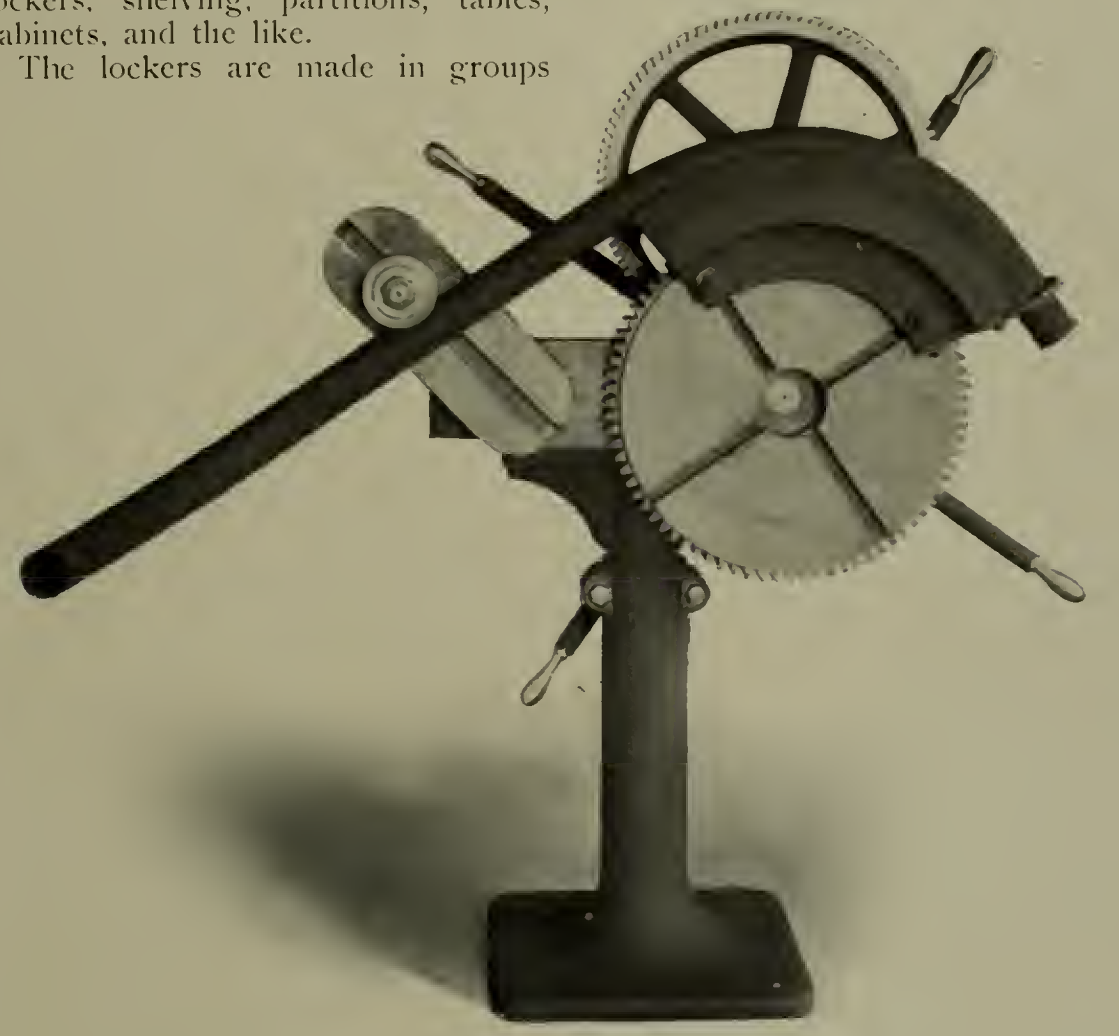
ings, known as the "Pen-Dar" system, is made by the company, including such specialties as metal lockers, shelving, partitions, tables, cabinets, and the like.

The lockers are made in groups and sizes according to requirements or specifications, and can be made entirely of open mesh or of sheet steel, and on the "unit" system.

A Pipe-Bending Machine

A MACHINE designed by Pedrick & Smith, of Germantown, (Philadelphia), for bending pipe or conduit cold is shown in the annexed illustration. Piping of steel, iron, brass, copper, or other material can be bent cold up to and including 2 inches in diameter. The machine is also adaptable by means of special formers for bending light angles, flats or T-bars.

The gearing is compound with a ratio of 25 to 1, thus giving the machine a powerful leverage. A boy can bend 2-inch pipe with little effort. The machine is operated by a hand wheel having four handles, compound gearing engaging the face plate upon which the bending quadrants are secured. The pipe is held in the quadrant at one end by a steel plate, while the resistance stud on the movable arm engages the other end. The various curvatures are obtained by adjusting the arm, which has a swing of three-quarters of a circle, supplemented by the movement of the resistance pin in the T-slot on the arm.



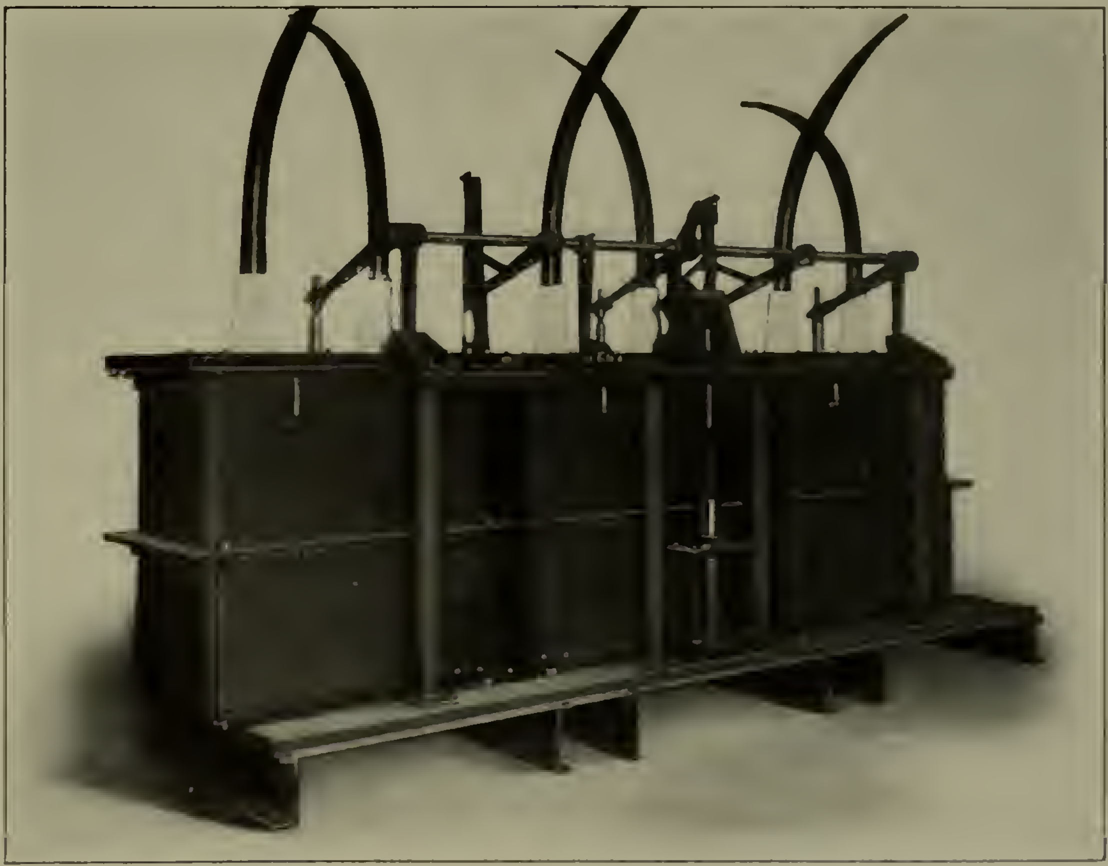
A PIPE-BENDING MACHINE BUILT BY PEDRICK & SMITH, GERMANTOWN, PHILADELPHIA

The machine is mounted on a telescopic stand, which can be raised or lowered to any suitable height. When the base is fastened, the upper part swivels. A universal arm or section for the stand is furnished so that, if so desired, the face plate can be placed in a horizontal position at any height from the floor.

Quadrants are furnished with the machine for 1-inch pipe with a radius of 6 inches, for 1¼-inch pipe with a radius of 9 inches, for 1½-inch pipe with a radius of 12 inches, and for 2-inch pipe with a radius of 14 inches. While these four quadrants are furnished with the machine, it is found that the smaller sized pipe can be readily bent in the larger size quadrants very satisfactorily. In fact few workmen will take the time to change the quadrants unless they desire a shorter radius than the larger quadrants will give them.

A New Electrically Operated Oil Circuit Breaker

THE circuit breaker shown in the annexed illustration was designed by the Westinghouse Electric & Manufacturing Co., of Pittsburg, Pa., primarily for the Ontario Power Company's work at Niagara Falls. It is intended to handle energy up to 60,000 H. P. per three-phase circuit, and will open a circuit under any conditions of overload or short circuit which may occur with a power house capable of delivering 200,000 H. P. The insulation to ground and between terminals is designed to withstand a break-down test of 150,000 volts, and the insulation between poles is twice that



A 60,000-H. P. ELECTRICALLY OPERATED OIL CIRCUIT BREAKER BUILT BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG, FOR THE ONTARIO POWER COMPANY, NIAGARA FALLS, ONTARIO

amount, since the poles are electrically separate.

The three poles of the switch are closed together by means of a toggle joint operated by a single, direct-pull solenoid. The switch is held in a closed position by the toggle being carried just beyond the center, and is tripped out by the tripping coil armature striking this toggle and knocking it backward, allowing the switch to open by gravity. Each pole of the switch gives a double break, each break being approximately 17 inches. The closing magnets require approximately 5000 watts direct current, while the tripping magnets require about 300 watts.

The oil tanks, of which there are three, are made of boiler iron lined with an insulating material, with barriers interposed between the stationary contacts. The contact parts are of their standard construction, having renewable arcing tips and contacts. The leads, with their insulation and the upper porcelain insulators, may be readily removed from the switch, giving access to the contact parts for inspection and repairs. The top covers of the tanks are made of treated soapstone slabs, part of which are also removable. Each tank is provided with an oil drain opening in the bottom, and an overflow just above the normal oil level. These openings are provided with standard 3-inch pipe flanges, but no pipe is provided. Each tank has an oil-level gauge and requires approximately 160 gallons of oil.

The total weight of each three-pole switch complete, the tanks being filled with oil, is approximately 15,000 pounds. The oil alone weighs approximately 4000 pounds.

A two-pole, double-throw, indicating switch is provided upon each three-pole oil switch for use in connection with the controlling and indicating devices. The circuit breaker is not automatic in itself, an overload relay operated from series transformers being necessary.

A Motor-Driven Grinder

A MOTOR-DRIVEN grinder built by the Jenney Electric Manufacturing Company, of Indianapolis, Ind., is shown in the annexed illustration.

The motor is of the company's standard "universal" type, provided with a high-speed winding, and with fully enclosed heads and dust-proof bearings. It is mounted on a cast-iron pedestal of convenient height, and of sufficient weight to hold the motor steady when in operation. Attached to the motor is a special adjustable tool rest and a cast-iron cup for water.

A MOTOR-DRIVEN GRINDER BUILT BY THE JENNEY ELECTRIC MANUFACTURING COMPANY, INDIANAPOLIS

The starter and line-switch are mounted on the pedestal by means of a substantial slate slab, thus putting a starting mechanism within easy reach of the operator. The grinder has a speed of 2700 revolutions per minute, and an emery wheel, 8 inches in diameter or smaller, can be placed on each end of the shaft. This arrangement also permits its use as a buffing or polishing lathe.

Where it is desired, a short foot is substituted for the pedestal, and the motor can then be mounted on the bench or on a post or side wall.

The Single-Phase Equipment of the St. Clair Tunnel

THE single-phase electric locomotive adopted by the St. Clair Tunnel Co. for the operation of the St. Clair tunnel, which connects the American and Canadian divisions of the Grand Trunk Railway system, will weigh approximately 62 tons, and will develop a drawbar pull of 25,000 pounds on a 2 per cent. grade at a speed of 10 miles per hour.

A motor will be geared to each axle, giving each unit an aggregate rated capacity of 750 H. P. They are of the Westinghouse single-phase, alternating-current, series-wound, compensating type of the same general character as the motors selected by the New York, New Haven & Hartford Railroad Co. for the operation of their line between New Haven and New York. Each motor will weigh complete, approximately 14,500 pounds, the armature weighing approximately 5000 pounds.

The motors are wound for 240 volts and 25 cycles per second, and have a nominal rating of 250 H. P. each, on the basis of usual electric railway practice. During operation a forced circulation of air supplied by motor-driven blowers enters at the rear, distributes itself thoroughly throughout the motor and escapes through the perforated cover over the commutator.

The essential elements of the control equipment include the collecting devices, the auto-transformers, the unit switches, the preventive coils, the reverser and master controllers. A multi-unit system of control is provided with pneumatically operated switches and circuit breakers, low-voltage control circuit, and other characteristics standard in Westinghouse practice.

Each locomotive unit will be equipped with a pneumatically operated pantagraph trolley to collect current from the overhead lines outside the tunnel and throughout the yards. A No. 0000 grooved overhead trolley wire will be suspended from a single $\frac{5}{8}$-inch galvanized, steel-strand messenger cable by hangers of varying length in such a manner that the trolley wire will be approximately horizontal. The messenger cable will be swung from structural iron bridges located throughout the yards. There will also be a small section of track equipped with a trolley line swung by catenary suspension from bracket arms which are supported on lattice-work poles.

For the operation of the electric locomotives a complete power plant will be installed by the St. Clair Tunnel Company, including two 1250-KW., 3300-volt, three-phase, 25-cycle, rotating-field, Westinghouse steam turbine units, running at 1500 revolutions per minute, with the necessary complement of switchboards, exciters, lightning protective appa-

ratus, etc. This station will also supply current to light the buildings, yards and tunnel, to operate motor-driven centrifugal and triplex pumps which drain the tunnel and approaches, and operate the sewage system, to run motors in the roundhouses, and for other purposes.

The new equipment will handle that portion of the Grand Trunk Railway system which connects the divisions terminating at Port Huron, Mich., and Sarnia, Ont., on opposite sides of the St. Clair River. The tunnel proper is 6032 feet long, and the line to be electrically operated measures 3.6 miles from terminal to terminal.

Six locomotives are to be furnished by the Westinghouse Electric & Manufacturing Co. The work of installation will be conducted under the supervision of Bion J. Arnold, of Chicago, consulting engineer for the St. Clair Tunnel Co., the plans and specifications having been prepared by him.

Protecting and Reinforcing Sleeves for Trolley Poles

TEN or twelve years ago, when began the first extensive use of metal poles for supporting overhead electrical conductors, it was assumed that, with an occasional coat of paint, the pole would continue in good condition indefinitely, and represent a permanent investment. Recently, however, this was found to be very far from the truth, and although data are scarce, it is a conservative statement that a large proportion of the metal poles now in position are fast reaching, in their present condition, the end of their usefulness.

The deterioration has occurred by corrosion at the surface level of the pavement in which the pole is set, and which, unfortunately, is also about the point of greatest strain. In some cases the poles have been found so badly pitted at the ground line that the shell of the pole could be punched through with an ordinary blow.

To reinforce poles thus weakened and to protect them from further corrosion, William D. Gherky, of Philadelphia, Pa., has designed a sleeve, 24 inches long and ¼ inch thick, to be placed over the corroded part. The annexed illustrations show the sleeve and the method of applying it.

The surface of the pavement around the pole is dug out to a depth of 10 inches by removing the concrete in which the pole was set, making the opening 24 inches square. The pole is then thoroughly cleaned and the sleeve is slipped over, centered, heated, and the intervening space between pole and sleeve filled with molten sulphur. The sulphur is roofed or beveled at the top.

PUTTING IN CONCRETE AT THE BASE OF THE RECLAIMED POLE. THE PORTABLE CONCRETE MIXER IS SHOWN AT THE RIGHT

POURING IN SULPHUR AROUND A REINFORCING SLEEVE MADE BY WILLIAM D. GHERKY, PHILADELPHIA. THE WAGON FOR MELTING THE SULPHUR IS SHOWN AT THE RIGHT

A concrete block is then formed about the sleeve, sloping upward so as to turn away from the pole, and finished with a cement surface. The effect of this block is to preserve the life of the sleeve; but even in the course of time, should the sleeve become corroded, it may be renewed, thus attaining the end originally sought, of permanency for the poles. The sulphur sets up very hard and becomes as a part of the metal itself, and its insulating qualities retard further electrolytic corrosion. It also makes a water-tight joint, so that moisture cannot enter.

In cooling and shrinking, the sleeve encompasses the pole with considerable pressure, stiffening it greatly. By actual test, an old and badly corroded pole so repaired withstood greater strain than a similar new pole unprovided with the sleeve. The device is applicable, of course, to new poles also, and in this case it possesses the same advantage over a sleeve shrunk on, or similar device. The sulphur acts as an insulator, retarding further electrolytic corrosion, and even if destroyed in course of time, the sleeve may be renewed without taking out the pole.

A Plug for Flashing Incandescent Lamps

IN the August, 1905, issue of THE ELECTRICAL AGE, was described a German device, recently placed on the market abroad, for flashing incandescent lamps. A similar de-

vice, illustrated herewith, manufactured by the Phelps Co., of Detroit, Mich., has been, however, on the market in the United States for the past two years.

The operating mechanism is very simple and consists of a small U-shaped thermostat, around which is wound an insulated resistance wire. The heating of this wire when the lamp is burning tends to straighten the U and breaks a contact, causing the lamp to go out. The thermostat then cools rapidly and contact is again made, the operation being repeated about fifteen times a minute.

The plugs will fit any ordinary lamp socket and hold any common incandescent lamp. Each plug is complete in itself and is independent of every other socket. The operating mechanism is adjusted at the

A PLUG MANUFACTURED BY THE PHELPS COMPANY, OF DETROIT, MICH., FOR LIGHTING AND EXTINGUISHING INCANDESCENT LAMPS MANY TIMES A MINUTE

factory and is guaranteed for six months.

Essentially the same device, mounted on a slate base, is also manufactured by the company in capacities from 1 to 10 amperes. This may be placed anywhere in the circuit and adjustment made while the current is on.

The company also manufacture sign frames and transparencies in which the flicker device is used. Another interesting product is the self-flashing "Hylo" lamp. This is provided with a large and a small filament. Inside the base is a device for charging the current from the large to the small filament at irregular intervals. The sign on which these lamps are used is thus never entirely dark, but the flashing is as equally effective as though the lamp were entirely extinguished.

Personal

Asa M. Mattice has resigned the position of chief engineer of the Allis-Chalmers Company, at Milwaukee, and will make his headquarters in New York, where, it is understood, he will engage in engineering work on his own account.

Joseph Cawley, formerly of James Bonar & Co., Inc., and the Pittsburg Feed-Water Heater Co., of Pittsburg, has assumed the position of vice-president of the Cadwallader Tin Plate & Metal Co., also of Pittsburg.

Irving Moultrop, of the Boston Edison Company, representing the steam turbine committee of the National Electric Light Association, has sailed for Europe to investigate turbines. It is the intention of the committee this year to report on the progress of the steam turbine here and abroad, also to include in its work an investigation of gas engines.

C. T. Mordock, of Terre Haute, Ind., has been appointed by President Blood to report on "Methods of Theft of Current" at the twenty-ninth convention of the National Electric Light Association, to be held in June next. Past President Ernest H. Davis will make a new compilation of the laws of the different States governing theft of current, bringing this compilation up to date. This is one of the most important subjects with which central stations have to deal, and the report will be very valuable.

John F. Gilchrist, of the Chicago Edison Co., has been appointed by President Wm. H. Blood, of the National Electric Light Association, as reporter on the "Free Installation of Electric Signs," Mr. Gilchrist's large experience with the Chicago Edison Co. will enable him to prepare a very interesting and instructive report on this subject for presentation at the twenty-ninth convention of the association, to be held at Atlantic City, N. J., June 5, 6, 7 and 8, next.

Robert L. Winkley, of the publicity department of the Pope Manufacturing Company (automobiles, bicycles, etc.), gave an informal talk before the Technical Publicity Association at a dinner at the Aldine Association at New York, on Thursday evening, January 18. He outlined the methods of advertising automobiles, and gave his opinion of the automobile magazines, New York daily papers, novelties, such as paper weights, etc., automobile races, new features in automobiles, the value of trade-marks, etc. Among the companies represented by members at the dinner were the Ingersoll-Rand Company, the Niles-Bement-Pond Company, the H. W. Johns-Manville Company, the General Electric Company, the Crocker-Wheeler Company, the Sprague Electric Company, the Yale & Towne Manufacturing Company, the John A. Roebling's Sons Company, and the A. S. Cameron Steam Pump Company.

The development of the Ontario Power Co. forms the subject of a very interesting pamphlet prepared by Paul N. Nunn, and issued by the Ontario Power Company, of Niagara Falls. It is a reprint of a paper presented at the last annual convention of the American Institute of Electrical Engineers. There are many illustrations, and the treatment is clear and concise,—characteristic of the author. An exceptionally interesting double-page half-tone illustration forms part of the pamphlet, affording a bird's-eye view of Niagara Falls, showing the power developments on the Canadian side.

Frederick R. Slater, late assistant to the electrical engineer of the Interborough Rapid Transit Co., of New York, has opened an office at 100 Broadway, New York, for the practice of electrical engineering. Mr. Slater had much to do with the installation of the electrical equipment of the New York Subway, and previous to this undertaking had been engaged in installing the third-rail system on the New York elevated railways.

The second award of the John Fritz medal has been made to George Westinghouse. This medal was established by the professional associates and friends of John Fritz, of Bethlehem, Pa., U. S. A., on August 21, 1802, the eightieth anniversary of his birth, to perpetuate the memory of his achievements in industrial progress. The award was made by the following board selected for the purpose. From the membership of the American Society of Civil Engineers:—Alfred Noble, Chas. Warren, Charles Hermany, C. C. Schneider. From the membership of the American Institute of Mining Engineers:—James Douglas, Charles Kirchhoff, E. E. Olcott, E. G. Spilsbury. From the membership of the American Society of Mechanical Engineers:—Robert W. Hunt, S. T. Wellman, James M. Dodge, John E. Sweet. From the membership of the Ameri-

can Institute of Electrical Engineers:—Charles P. Steinmetz, Charles F. Scott, B. J. Arnold, John W. Lieb, Jr. The medal is of gold, and with it is presented a certificate of the award. The medal was awarded to George Westinghouse for "The Invention and Development of the Air Brake."

Trade News

The Allis-Chalmers Co., of Milwaukee, Wis., have changed the location of their Salt Lake City, Utah, office, which is in charge of Frank Marcy, district manager. The new address is the Dooly Building, 117-119 East South Second street.

The Le Valley Vitæ Carbon Brush Co., of New York, has recently been reorganized and important changes, both in factory and office organization, have been made, with a view of improving the company's manufacturing methods and general service to patrons.

The increasing business of the Westinghouse Electric & Manufacturing Co., of Pittsburg, Pa., in the territory covered by the Columbus, Ohio, office has necessitated moving into larger quarters. Since January 15, they have been located in the Columbus Savings & Trust Building.

James L. Pilling has associated himself with the Railway Appliance Co., of Chicago, Ill. The company announce that they will be pleased to receive inquiries relative to improved compressed air locomotive turntable devices, and hoisting engines, both portable and stationary, for all purposes, all being equipped with the Pilling improved engines.

An important order recently secured by the Canadian Westinghouse Co. was obtained from the Vancouver Power Co., of Vancouver, B. C. This order included a 1500-H. P., 2200-volt, revolving-field, engine-type generator, which will be direct connected to a Pelton water wheel. This is a duplicate of the generators now in operation in the power plant of the latter company and will operate in multiple with them. The order includes switchboards, air-blast transformers of 550-KW. capacity, and a 1000-KW., 60-cycle rotary converter to operate at 550 volts. This converter will furnish power for railway work and will be controlled direct from the switchboard. For the lighting of the Welland Canal, near St. Catherine, Ontario, over 600 alternating-current series arc lamps have been provided by the company. These have been in operation for the past few months and have given splendid service.

The new power station at Williamsburg of the Brooklyn (N. Y.) Rapid Transit Company has been supplied with coal-handling equipment by the Mead-Morrison Company, of New York and Boston. The same company has similarly equipped the Gold street station of the Brooklyn Edison Company and the new Waterside station of the New York Edison Company.

The Abner Doble Company, of San Francisco, announces that it has opened up a branch office at Los Angeles, in the Pacific Electric Building. The company's business in the water wheel and machinery supply line has increased to such an extent that it became necessary to have better representation in the Southwest. The new branch will have for its field Southern California, Arizona and New Mexico, and parts of Nevada and Mexico. L. Cummins will have charge of the office.

The Green Fuel Economizer Company, of Matteawan, N. Y., long famous as the originator and builder of the fuel economizer, a device for recovering the waste heat in the flue gases from steam boiler plants, some time ago began the manufacture of fans, blowers and exhausters upon a large scale. This company had always been a large user of such apparatus and entered upon its manufacture with the belief that users would appreciate a grade of design and workmanship higher than that prevalent before.

Only comparatively recently has the name of the Allis-Chalmers Co., of Milwaukee, Wis., come to be associated with hydraulic turbines and the development of water powers. In the two years which have passed since the company first entered the hydraulic field, its progress has been great, the aggregate horse-power in hydraulic turbines installed since that time and now under construction, reaching 181,400, the greater portion of which is represented by contracts obtained within the last six months. The company has produced a line of hydraulic power machinery suitable for operation under every conceivable condition, by means of impulse or tangential wheels and those of the central discharge type. Following are a few installations recently completed or in process of building, which will indicate the scale on which this branch of production has been undertaken:—California Gas & Electric Corporation, San Francisco, Cal., one single, horizontal scroll case turbine, 9700 H. P.; Milford Construction Co., Milford, Me., eight twin, vertical turbines, 7000 H. P.; Southern Power Co., Charlotte, N. C., six twin, horizontal turbines, 31,200 H. P.; Edison Electric Co., Los Angeles, Cal., four twin, horizontal impulse wheels with deflecting nozzles, 43,000 H. P.; Great Northern Power Co., Duluth, Minn., three vertical, single scroll case turbines, 39,000 H. P.; Guanajuato Power & Electric Co., Guanajuato, Mex., one single, horizontal scroll case turbine, 5000 H. P.; Niagara Falls Power Co., Niagara Falls, N. Y., replaced parts for the reconstruction of five vertical, single turbines, 27,500 H. P.

The American Stoker Company, of Erie, Pa., has acquired from the McMyler Manufacturing Company, of Cleveland, Ohio, the patterns, drawings, patents and good will for the manufacture of the "Victor" chain grate stoker. Mr. F. Girtanner, the designer of the stoker, has entered the employ of the American Stoker Company. The stoker will hereafter be known as the "American" chain grate stoker, and will be produced concurrently with the company's underfeed stoker.

For use in that class of service, including crane and hoisting work, where the conditions are extremely severe, the Northern Electrical Manufacturing Company, of Madison, Wis., has developed a line of box type motors. These equipments are completely enclosed and thus dust proof, and are frequently built weather proof. This class of motors has a very substantial armature shaft, liberal bearings, and a compact, although accessible, arrangement of the motor parts.

Announcement has been made of the formation of the Electric Cable Company, of Bridgeport, Conn., which succeeds the Magnet Wire Company and the Peerless Electric Company, both of New York. The company is erecting a large factory in Bridgeport, where it will manufacture magnet wire, field and armature coils and "Voltax," the new non-rubber insulation. The New York office will be at No. 42 Broadway. The officers of the company are:—President, Edwin W. Moore; vice-president, Frederick H. Cowles; treasurer, J. Nelson Shreve; secretary, H. S. Williston. The directors include Alfred Skitt, John Carstensen, G. Tracy Rogers, George C. Edwards, Russel A. Cowles, Edwin W. Moore, Frederick H. Cowles, J. Nelson Shreve and H. S. Williston.

New Catalogues

"Reliance" Corliss engines, built by the Allis-Chalmers Co., of Milwaukee, Wis., are illustrated and described in a bulletin recently sent out. These engines differ from former designs in that they have higher rotative and piston speeds.

Single-phase induction motors of 1-10 and 1/8 H. P. are illustrated and described in a bulletin recently sent out by the Emerson Electric Manufacturing Co., of St. Louis, Mo. The motors are provided with an automatic starting device which enables them to start under full load.

A series of pamphlets recently issued by the Crane Co., of Chicago, Ill., are devoted to non-return and direct return steam traps, quick opening hot water radiator valves, automatic and emergency valves, drip pockets, expansion joints, sediment traps, and pipe bends. The emergency valves are operated by steam, water, air, or electricity.

"In Vaudeville" is the unique title of a little red-covered pamphlet sent out by the Buckeye Engine Co., of Salem, Ohio, telling of their beginning of the manufacture two years ago of electric blue-printing machines. Another pamphlet, with the cover title "The Sun That Never Sets," describes the machine and shows its construction.

A pamphlet entitled "System in Contracting" was recently sent out by Frank B. Gilbreth, of New York, a diagram on the cover showing the connection between his various departments. The illustrations show work done by him under a cost-plus-fixed-sum contract, in one case the entire town of Spragues Falls, Me., being built in this way. Other work includes manufactories and water-power development.

A new type of variable-speed motor is illustrated and described in bulletins recently sent out by the Lincoln Electric Manufacturing Co., of Cleveland, Ohio. Variation in speed is obtained by moving the armature in or out between the field poles. When the armature is drawn out, the resistance to the magnetic flux increases and increased speed is obtained. The motors are built in various sizes, with speed changes from 2 to 1 up to 10 to 1 and greater if required, and for 110, 220 and 500-volt circuits.

Hammers in great variety are illustrated in a catalogue recently issued by the David Maydole Hammer Co., of Norwich, N. Y. Those listed are for bricklayers, farriers, machinists, blacksmiths, boiler riveters, coopers, tinsmiths, carpenters, joiners, masons, tilesetters, prospectors—in short, for every possible use. Another pamphlet, besides illustrating the hammers, contains a number of tables of interest to engineers, machinists, carpetnters, and other users of hammers.

Transformers built by the Westinghouse Electric & Manufacturing Co., of Pittsburg, Pa., are illustrated and described in a recent circular. They range in capacity from 0.6 KW to 500 KW. In the larger sizes the case is corrugated to increase the radiating surface, but in the smaller sizes the smooth case surface is sufficient to radiate the heat generated in the transformer.

Industrial railway equipment built by the C. W. Hunt Company, of West New Brighton, Staten Island, N. Y., is illustrated and described in a catalogue recently issued. The equipment includes rolled steel and cast plate track, turntables, iron frame scales, electric locomotives, and cars for a great variety of service. The illustrations are numerous and show many installations of industrial railways, and also cars of standard type and those built for special work.

A new catalogue recently issued by the Interstate Engineering Co., of Cleveland, Ohio, deals with their various lines of work. These include cranes, of the locomotive, wrecking, gantry, cantilever, pillar, and jib type, derricks, dredges, hoisting and conveying plants, grab buckets, transfer tables and turntables, locomotive coaling stations, railroad pile drivers, concrete mixers, elevating and conveying machinery, mine surface equipment, structural steel work, including buildings and bridges, lock nuts for bridge work, and patent clamp hooks for lifting concrete or stone blocks.

Central Station Advertising

In connection with the twenty-ninth convention of the National Electric Light Association to be held at Atlantic City, June 5, 6, 7, and 8, it is proposed to repeat on a more extensive scale the exhibit of central station advertising that was given with so much success last year at Denver for the first time. Steps are now being taken to carry out this purpose, and it is believed that the exhibit will prove attractive and instuctive to central station managers. It is proposed to divide the exhibit into two sections, one showing the work done by the larger companies which maintain their own force for such work, and issue and prepare their own bulletins, and the other bulletins and material furnished by the new concerns that have sprung up lately to supply the smaller stations with this class of matter, many of which have already done very effective work. In addition to this a display will be made of posters, large newspaper advertising and the original drawings and sketches employed in the bulletins.

Legislation to Preserve Niagara Falls

The joint resolution calling upon members representing the United States on the International Waterways Commission to report to Congress upon such action as in their judgment is necessary and desirable to prevent the further depletion of water flowing over Niagara Falls, and also directing them to exert all possible efforts, in conjunction with the members of the commission representing the Dominion of Canada, if practicable, for the preservation of the falls in their natural condition, was recently favourably reported by the Committee on Rivers and Harbours.

The report says:—

"Numerous petitions have been referred to this committee protesting against the use of the waters of Niagara River for power purposes. The opposition has been so vigorous and so general as to cause the President to direct attention to the subject in his message, and also to justify action by Congress. It has been alleged that the utilization of the waters under privileges already granted may cause the cataract on the American side to disappear entirely.

"The members of the committee regard this resolution as the most practical and efficient step to be taken at this time to prevent further injury. It is believed that the Canadian commissioners will join with those from the United States in recommending such measures as will secure the object sought, and that a report can be made at an early date which will enable Congress to act intelligently in the premises."

Electricity's progress in Japan is well illustrated by the statement that all Japanese cities with a population of more than 10,000 are lighted electrically. Besides, many of the towns have electric street car lines.

The New York City Municipal Lighting Plant

By ARTHUR WILLIAMS, of the New York Edison Company

A Reply to a Paper on this Subject by Prof. G. F. Sever, of the Lighting Commission, read before the Society of Municipal Engineers.

LIGHTING the streets of a municipality is a commercial question. There is no sentimental reason for or against the manufacture of light by the municipality or its purchase from a private corporation. The consideration is one of relative cost and of service standards.

Service standards are of even greater importance than cost. One of the essentials in a modern, well-governed municipality is good light, continuously supplied. President Roosevelt, when police commissioner of New York, once said that an arc lamp was equal to a policeman. In New York an arc lamp costs $100 a year, a policeman twelve times as much.

Were the service poor, the city would be compelled to employ all necessary means, at whatever cost, to improve it. This, however, cannot be a question here, for the lighting standards of our city are generally recognized as the highest in the world.

No street lighting was ever subjected to a severer test than that of New York on the day and night of the blizzard, occurring in the early part of 1905. It will be remembered that such trains as succeeded in getting through—very few did—consumed from ten to fifteen hours between New York and Albany. The street car system was compelled to suspend operations, cars were abandoned on every hand, and yet not a single street lamp failed to give the usual service. During the storm a prominent city official made a personal inspection of a great many streets, and reported every lamp burning brilliantly.

INSURANCE AGAINST INTERRUPTION

Still another question may enter into the problem—assurances against interruption from transportation troubles, the weather, or other causes. Would such assurances be of a more substantial nature were the city itself to manufacture the light it requires?

Here it should be pointed out that, saving large expenditure, the Engineering Commission fails to include anything like the coal storage capacity of the private companies. The New York Edison Company, in addition to carrying many thousands of tons in each of its generating stations—the bunkers of one station containing 15,000 tons—has provided a storage on the New Jersey shore of the North River of from 200,000 to 300,000 tons. From here coal can be taken in barges and delivered directly into the company's principal generating station. The supply is sufficient for two-thirds of a year, a period much beyond the possible duration of any interruption in the source of supply.

A CHEAP AND INADEQUATE SYSTEM ADOPTED

The Commission is composed of engineers of the highest technical standing, and one should, therefore, hesitate in criticising the plans adopted. Yet the system proposed is not equal to, and does not give, the assurances of the present system.

It is understood that the change is made to secure a cheaper method than that used by the private companies. For example, it would not be possible to use storage batteries, without the aid of which the best service cannot be maintained, and in fact without which no system supplied from a high-tension generating station can be operated without constant probability of interruption.

It does not seem fair to compare a system, which, at enormous cost, has been developed to provide these advantages with one, which, to obtain cheapness, omits them. The comparison is not "'on all fours."

PRESENT STREET LIGHTING NOT EXPENSIVE

The cost of illuminating our streets is extremely low. For such illumination as we see around us on every hand, of an average unequalled in any other city, the per capita cost for each resident of Manhattan Island is less than $1 yearly. It is about two-tenths of a cent daily. A 1-cent tallow candle burned nightly for each resident, would increase the present cost of municipal lighting fully five times.

It is repeated that the comparison should be made between systems of like efficiency giving equal standards of illumination, and equal assurances of continuous service.

THE OMISSION OF TAXES

One must disagree also with the views of the Commission that the loss of taxes should be omitted from the operating cost of this plant. Almost without exception, curiously, taxes lost are omitted from all municipal ownership calculations. Advocates of municipal ownership basing their premises largely, if not entirely, upon the expected, and in practice imaginary, profits to be derived from the enterprise, give little heed to the value of the taxes paid by private corporations.

Essentially there is no difference between such taxes and profits, real or alleged, from municipal ownership. From the operation of the street railways, the city of Glasgow last year received in the form of "profits," so-called, less than one-sixth the amount paid in taxes by the rapid transit companies of the borough of Brooklyn alone, and the population of the two is about the same. In the same period, Great Britain, the home of municipal undertaking, received less from all her municipal street railways than the aggregate taxes paid alone by the street railway corporations of our own State of New York. And to achieve their results, the British municipalities were compelled to invest $140,000,000 of the taxpayers' money—the State of New York invested not one cent.

A FAIR EXAMPLE OF MUNICIPAL OWNERSHIP

Freiburg, the so-called "model city of Germany," where everything, from the gas and electric light works to pawn shops, cemeteries, and building lots, is owned by the municipality, received in 1904 from the operation of the gas and electric light works and the street railway system, $10,359.99, or less than 2 per cent., which is called a "profit." In taxes alone, in similar enterprises, American companies would have paid more than $50,000. Had Freiburg received such a sum from these enter-

prises, one can imagine what a stir would have been created throughout the civilized world, and, yet, paid by private corporations, it is not taken into account.

Curiously, what seems to have been real profits at Frieburg were made from the cemeteries and water works. These are two of the absolute necessities of our daily life, and they should be obtained by the public at the smallest possible cost. Yet out of $147,676 received from the two departments in charge of these matters, $84,755, or 57 per cent. were reported as net profits.

This result is but another indication that municipalities are not able to manage such technical industries as gas and electric light, railways and telephones that require administrative and professional skill of a high order.

UNDERESTIMATED OPERATING COSTS

The Commission estimates that the mere operating costs of an arc lamp, including labor and fuel, are approximately $35 annually—not including interest or depreciation.

For labor alone, the cost of operating the municipal lighting plant which now supplies the old Brooklyn Bridge is in excess of $50 annually, for each arc lamp supplied. This figure was obtained from the "City Record," in which are itemized the expenditures for labour.

The Commission states that the nine small electrical plants now operated by the municipality in the borough of Brooklyn cost annually $100,000. But the same, or better, service would be rendered to the city by the local electric light company at a cost not exceeding $70,000.

The largest municipal street lighting plant in the world is that of the city of Chicago. For a long time the city authorities have claimed that it is operated with great economy, and, yet the report for 1904 states that the operating cost of an arc lamp was $54.36, or $20 more than the Engineering Commission allows for operating costs in this city. The Chicago figures do not include water, amounting to approximately $4 annually for each arc lamp. Furthermore, relative expenses are much greater in New York than in Chicago.

DEPRECIATION

Another point at issue is the allowance for depreciation. This was originally placed at 7½ per cent. by the distinguished chairman of the Commission; but more recently the Commission has reduced the figure to 6 per cent. Within twenty years the New York Edison Company has changed its generating system several times, and another change is now in sight. The lowest expenditure estimate of the Commission is now $7,567,000, and the annual difference between these percentages—6 per cent. and 7.5 per cent.—amounts to $113,505.

THE COMMISSION'S REPORT

The report of the Commission as thus far submitted, has been divided into four sections—A, B, C, and D. A and B refer to Manhattan Island and the Bronx, C and D to Brooklyn and Queens.

A and C give the cost of substituting the present electric street lighting, now privately supplied, and the electric and gas lighting of public buildings, with municipal service; B and D give the cost of substituting electric light wherever gas is now used, on the streets as well as in the public buildings.

Little need be said about either C or D, as they admit a loss of almost $100,000 annually were the city to replace the present service with that of a municipal plant, and many items are omitted, which, if included, would increase the loss to more than $250,000 annually. According to the Commission's estimate, the city must make an investment of $9,485,000 to accomplish this result.

Report A, the first submitted, calls for an investment of more than $4,000,000. It admits operating expenses of $892,000 for a service that can now be purchased from the private companies for $650,000, or at most, $700,000. This section, therefore, need receive little further attention.

It is section B in which we are more directly interested. It calls for an investment of $7,567,000, and claims an annual saving of $434,000.

The report does not include the cost of subways, which would be not less than $3,750,000; it does not provide for the equipment with wires and fixtures of the buildings now using gas, nor for the changing of the present electrical apparatus, including elevator and other motors. On a conservative basis this equipment would cost, including, properly, engineering expenses, not less than $2,750,000. Thus the ultimate investment by the city through the introduction of a municipal generating plant would be $14,067,000, to obtain a so-called "profit" of $434,000,—about 3 per cent.

But there would be no such differences as $434,000. The entire cost of lighting the city last year was $1,703,000. It is upon this basis that the foregoing hypothetical "profit" is obtained by the Commission. The legislative reduction in the price of street arc lamps lessens this sum by $204,000; the reduction in incandescent lighting will lessen it from $15,000 to $20,000 more, and there has also been a reduction in the price of public gas lighting. But allowing only for the change in the cost of arc lighting the total margin claimed by the Commission becomes reduced to $230,000, hardly more than 1½ per cent. on the ultimate investment.

ITEMS OF COST OMITTED

Here again, however, we find items omitted. There is no allowance for taxes lost, which amount to approximately $80,000 annually; there is no allowance for general expense, executive and administrative, which for a plant of this size would amount annually to not less than $75,000; there are no changes incidental to the installation expenditure—$2,750,000,—upon which must be allowed 10 per cent. annually, or $275,000; likewise, all subway costs are omitted, which, on the basis of 10 per cent. for interest, depreciation and taxes, would be $375,000; there is no allowance for the upkeep of the underground cable system, which would average not less than $2 annually an arc lamp, or $30,000 altogether. The Commission allows the absurdly low figure of $8 annually for upkeep, maintenance, repairs and attendance for each arc lamp, yet no private company can render this service for as little as $12 annually. Adding the additional $4, we must again increase the expenses of operating the municipal plant by $60,000.

The aggregate of these additional items is $895,000, making an annual net loss to our taxpayers of $665,000, instead of a gain as reported by the Commission of $434,000.

A résumé shows no reason whatever from the standpoint of quality of service, for changing from the present system, but from the standpoint of assured service shows every reason for continuing it. In fact, in regard to both, the city is far better off than were it to adopt the plan of the Commission. Finally, there is no financial reason for a change. Not only would the city make no profit from the operation of the plant, but it would place itself in a position to lose large sums annually.

Such considerations as to the addition of a large, complicated department, with a great increase in the number of municipal employees, and a widened field for political corruption, have not been referred to as a factor in presenting the foregoing conclusions.

THE ELECTRICAL AGE

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The Electrical Age Co.
New York and London

The Electric Automobile

By HIRAM PERCY MAXIM

FIG. 1.—THE "ELECTROBAT," BUILT IN 1895 BY MORRIS & SALOM, PHILADELPHIA

THE future of electricity among the motive powers for automobiles is becoming one of the interesting engineering questions of the times. The present extraordinary development of the gasoline engine for vehicle propulsion leads to speculation as to how electricity is likely to fare in this field in the future. In considering this matter, it is significant to review the record of the electric automobile to date.

In 1895, three types of practical and fairly able motor vehicles were in use. The motive powers of these were electric motors taking current from storage batteries, steam engines, and gasoline engines. While limited in mileage, and, therefore, in its field, the electric automobile nevertheless stood at the head of the list in reliability, in certainty, and in general practicability.

Conspicuous among builders at the time were the following:—Morris & Salom, of Philadelphia, with a very practical electric carriage; C. E. Duryea, of Springfield, Mass., with a gasoline carriage, highly developed for the times; Haynes & Apperson, of Kokomo, Ind., with a gasoline carriage; Whitney, of Boston, and others with steam carriages of very light weight and pleasing appearance; and the writer, in Hartford, with an electric and a gasoline carriage, the first of the existing family of "Columbia" gasoline and electric automobiles.

The Morris & Salom "Electrobat," as it was termed at the time, was equipped with two plain series motors, pivoted from the driving axle and suspended from the body of the vehicle exactly as were the motors of electric street cars. Each motor had single-reduction pinion-and-gear drive to one of the driving wheels. The arrangement still exists to-day in those vehicles which have two motors with gear-and-pinion drive.

A vertical, street-car type of controller was used, the various speeds being obtained by multiple-series grouping of the batteries. The circuit was completely broken between each speed and gave, in consequence, more or less of a jerk between notches. The batteries were of 48 cells, having small plates of the ordinary stationary type in use at the time, and represented the highest development of the art at that period of stationary practice. They were carried in the main body of the vehicle back of the seat, giving a pleasing and simple appearance as compared with the mechanical carriages.

A unique feature was that the front wheels were for driving, while the rear ones were for steering, which was accomplished by a fore-and-aft operating hand lever, in no way suggestive of the direction of the steering. The wheels had wood spokes, and the tires used were single-tube pneumatics, a bad puncture requiring a return to the factory for repairs. The rim was a simple crescent, and getting the tire over the edge into place was a heroic undertaking.

The mileage on one charge was about 20 under favourable conditions, and a speed of approximately 10 miles an hour was attained. In operation, the vehicle was fairly quiet, the gears and pinions making all the noise. Compared with the mechanical carriage, it was considered very quiet and smooth running. Its operation, simplicity, and freedom from conspicuous mechanism were con-

FIG. 2.—THE "ELECTROBAT" NO. 1, OR EXPERIMENTAL WAGON, BUILT BY MORRIS & SALOM

sidered great points in its favour. Mechanically it was extremely simple and direct, since the motors and gears were all accessible and reduced to a few number of parts. Figs. 1, 2, and 3 show the types of vehicles produced at the time by Morris & Salom. The original of the present-day piano-box runabout will be noted.

The "Columbia" electric phaeton, shown in Fig. 4, was designed by the writer, as much as possible on horse-carriage lines. A single, series-wound motor was used, instead of two motors, and the drive was through a compensating gear to the rear driving wheels. The motor ran at very high speed and was, in consequence, light. It was held directly upon the rear axle, the entire spring suspension being what could be obtained from the tires.

FIG. 3.—ANOTHER EARLY TYPE OF ELECTRIC VEHICLE BUILT BY MORRIS & SALOM

The armature shaft of the motor was hollow, and the revolving driving axle passed directly through it. The double-reduction gearing was located in a housing beside the motor, the secreting of everything in any way suggesting the mechanical being the end striven for.

Batteries of 36 cells, of 9 plates each, were carried in the box body. The regular "Chloride" battery of the period was used, separators and all, the latter, curiously enough, in view of modern practice, consisting of thin wood with sheet asbestos over the positives.

A horizontal, drum-type of controller grouped the batteries to give one-quarter, one-half and full voltage, the circuit being broken completely between each notch. The speeds were 3, 6, and 12 miles an hour, which gave a distinct jerk and strain between notches. The mileage on one charge was approximately 25 on ordinary city streets.

In both these types of vehicles fairly satisfactory performance was rendered while in the hands of their respective builders. When under the eye of an experienced and skillful attendant at home, and when given consideration while driving on the road, they seemed to be entirely practical vehicles. With their model as a basis, Morris & Salom began the development of a line of public vehicles to be used as cabs, while the original Pope Manufacturing Company, of Hartford, Conn., began the development of a line of pleasure carriages.

While this was going on, the gasoline and steam engines were of course also rapidly improving and developing. In the latter part of 1895, a race was organized by the Chicago "Times-Herald," and the results well indicate the status of the competing motive powers of that time. Of about eighty-five contestants who signified their intention of entering, something like eight or ten appeared at the start. Morris & Salom and Sturgis started with electric vehicles, but failed to finish the course of 58 miles, because of battery run-outs. A heavy snow had fallen the previous day, which increased power consumption to an extent that the relays of batteries, provided on the basis of ordinary road conditions, proved inadequate. Mechanically, they performed with complete satisfaction, and had the weather been favourable, they would probably have finished first, in spite of their slower speed.

The steam machines failed completely. Two of the gasoline machines, one a Duryea, and the other an imported German Benz, succeeded

in finishing the 58 miles during the course of the day. The Duryea machine was the winner and covered itself with well-deserved glory. Each, however, had suffered all manner of breakdowns during the race, but due to the skill, experience, and dogged persistence of their drivers, they were repaired and kept going until they finished. The electric had failed on account of the snow, but had suffered no breakdowns, while the gasolines had broken down several times, but had recovered, gone on, and finished 58 miles before nightfall.

In the latter part of 1896 and 1897, Morris & Salom appeared with a line of electric cabs, shown in Figs. 5 and 6, which were regularly installed in a public cab station in New York. Simultaneously the first lot of "Columbia" electric phaetons, one of which is shown in Fig. 7, were placed upon the market in regular form. They were among the first automobiles to be manufactured in quantity in the United States.

The cabs will be recognized as the forbears of the present electric cabs in use in New York to-day in large numbers. In essentials they were like the original "Electrobats," in that they had two motors, hinged upon the driving axle and connected independently, each to a driving wheel by single-reduction pinion-and-gear drive. They steered from the rear end and carried the battery in a box made a part of the body proper.

A new step had been taken in the battery design. Instead of using what had been called a "Chloride" positive and a "Chloride" negative—which were in effect pasted plates—an attempt had been made to prevent rapid washing out of the material in the positives by using a Planté formation. Fluted ribbons of lead were coiled in the shape of buttons, several of which were pressed into holes in a grid of antimonious lead and there electrochemically formed. The resulting plate, while heavier per ampere hour than the original chloride, was structurally stronger and of much longer life, since the active material could not be softened up and washed out as easily. Hard-rubber separators made their appearance also, in an attempt to avoid short-circuiting troubles. These batteries had a capacity of approximately 2.7 ampere-hours per pound at the usual rate of discharge which they were subjected to in the vehicle. The plates of these and others contemporaneous with them, but not as successful, are shown in Figs. 8, 9, 10, 11, and 12.

The "Columbia" machines were also very like their originals. The motor had been moved from the rear axle and mounted in a so-called "torpedo," just ahead of the axle. A compensating gear was built in the torpedo with pinions at either end of the latter, driving the rear wheels by single-reduction pinion and gear.

The motor had been enlarged and the torque and speed characteristics improved over the original. A much higher torque was obtained from a given current, with corresponding reduction in speed. In climbing a grade, the carriage would tend to run more slowly, but take a less current. In practice this was found to assist the batteries, so that, in a long run, more mileage and a higher average speed were actually obtained.

The battery in these pleasure phaetons had been increased to 44 cells so as to charge from a 110-volt circuit, and the Planté positive plate was added, as in the cabs. To still further protect the battery from injury, due to ignorant overcharging and discharging, a device was added for which great hopes were entertained at the time. This device consisted of a recording watt-hour meter, which would record accurately the watt-hours discharged from the battery when running the vehicle, but which would under-record, by about 33 per cent. in the reverse direction, the watt-hours charged back into the battery.

By this means it was thought that a non-technical owner would be able to tell just when his battery had been recharged sufficiently to make good what had been taken out of it. The wattmeter dial was graduated so as to read in fractional parts of a complete charge, so that it was possible (in theory, be it said) to tell how much charge he had left in his batteries at any time. When recharging the battery, the meter worked backward toward the "full" mark, it should be understood, and, as stated above, at a rate 33 per cent. slower per watt-hour than it worked ahead. This, of course, was for making good the losses in the battery.

Much was hoped for these pleasure carriages, as every safeguard seemed to have been provided. It was thought that ordinary intelligence was all that would be required to operate and maintain the vehicles satisfactorily. They had a speed of 12 miles an hour, and it was calculated that they ought to run 30 miles on a single charge on good roads.

FIG. 4.—THE FIRST "COLUMBIA" ELECTRIC AUTOMOBILE, BUILT IN 1895 BY THE ORIGINAL POPE MANUFACTURING COMPANY, HARTFORD, CONN.

When these carriages were turned over to the general public to operate and maintain, some very surprising discoveries were made. It was found that the batteries could not be charged by hard and fast rules, but that judgment, based upon experience with storage batteries, was necessary. Their mileage capacity was such that more often than not, their entire capacity was used on a single run, which, of course, was conducive to about every ill a storage battery was heir to. As expert knowledge of the treatment of the diseases of storage batteries was at that time a very scarce commodity, battery troubles

FIGS. 5 AND 6.—THE FIRST ELECTRIC HANSOM CAB AND BROUGHAM. BUILT BY MORRIS & SALOM IN 1896. THE ORIGINALS OF THE PRESENT ELECTRIC HANSOMS AND BROUGHAMS IN USE IN NEW YORK CITY

were encountered upon all sides. It was only when an owner possessed technical knowledge and the right temperament that satisfactory performance was given. As frequently happens in all businesses, however, the sales department could not be induced to discriminate.

In the case of the electric cabs in New York, the experience was similar. Labour of the requisite skill and experience to keep the apparatus at its best was not obtainable. Battery and mechanical troubles both occurred. The service was, moreover, infinitely more severe than pleasure carriage service, from every point of view. In a short time every organ in the vehicle, battery and station apparatus showed some kind of trouble. Everything proved itself susceptible of considerable improvement. Wire wheels gave out, tires would not last a week, axles broke, motors burned out, controllers arced and burned, wiring grounded, gases from charging exploded, and golden opportunities for improvement were presented every five minutes of the day and night.

The possibilities of the scheme were not dimmed by these difficulties, however. It was obvious that electric vehicles could be designed, built, and operated to give better service than horses. The men back of the project had both money and nerve, and so new vehicles and better operating facilities were undertaken.

This experience in both the pleasure and public carriage service marked the close of one, and the beginning of another, important chapter in electric vehicle development. Two distinct fields were being developed vigorously and systematically. Up to this time, 1897 and 1898, although far from being what might be said truly reliable and certain, no other motive had equalled electricity in these features or in the number of vehicles in use.

In the next year or two, the field of the electric carriage was entered by several builders. The possibilities had become apparent and the names of Riker, Baker, Waverly, Sperry, and Woods become known in the growing industry. One of the most prominent of these was the Baker, shown in Fig. 13, the lightest automobile that had been produced up to that time.

Competition began, and, in its wake, more rapid improvement and development. Storage batteries, especially for vehicle use, appeared upon all sides. The pasted plate appeared in various forms with higher capacities per pound, and various lengths of life. Sperry, Porter, Crowdus, and others appeared, in spite of the famous Brush patent held by the Electric Storage Battery Co., who made the "Chloride." The Planté plate in various forms also was presented by Willard, American, Chamberlain, Reed, and others, in addition to the Electric Storage Battery Co.

In almost all these batteries the aim was to produce a lighter battery of greater capacity by increase of active surface and decrease of structural parts. The separators were trusted to keep the fragile, active material in place. The capacity and reduction in weight were obtained, and in some cases the active material was maintained in place and prevented from causing short circuits. But although kept in place it was not usually kept active, and loss of capacity followed quickly in most of them.

By this time, motors of very good characteristics had been produced by such companies as the Westinghouse, General Electric, and Eddy, and traction constants had become well established. Controllers which would not burn up were available also from the electric companies, while familiarity with the larger dimensions necessary for practical wiring, battery mounting, brakes, motor suspension, and spur gearing made them acceptable.

By 1899, about every form of horse pleasure carriage had been duplicated in the electric. The cabs in New York had been improved and installed in several of the other large cities. The electric had forged ahead of the gasoline and the steam in the number of vehicles in use. It had not, however, performed anything which the horse had not already done, except perhaps in somewhat higher speeds and increased convenience. It cost fully as much a ton-mile or passenger-mile as the horse, and in some cases much more, and it could not go beyond the confines of the city streets.

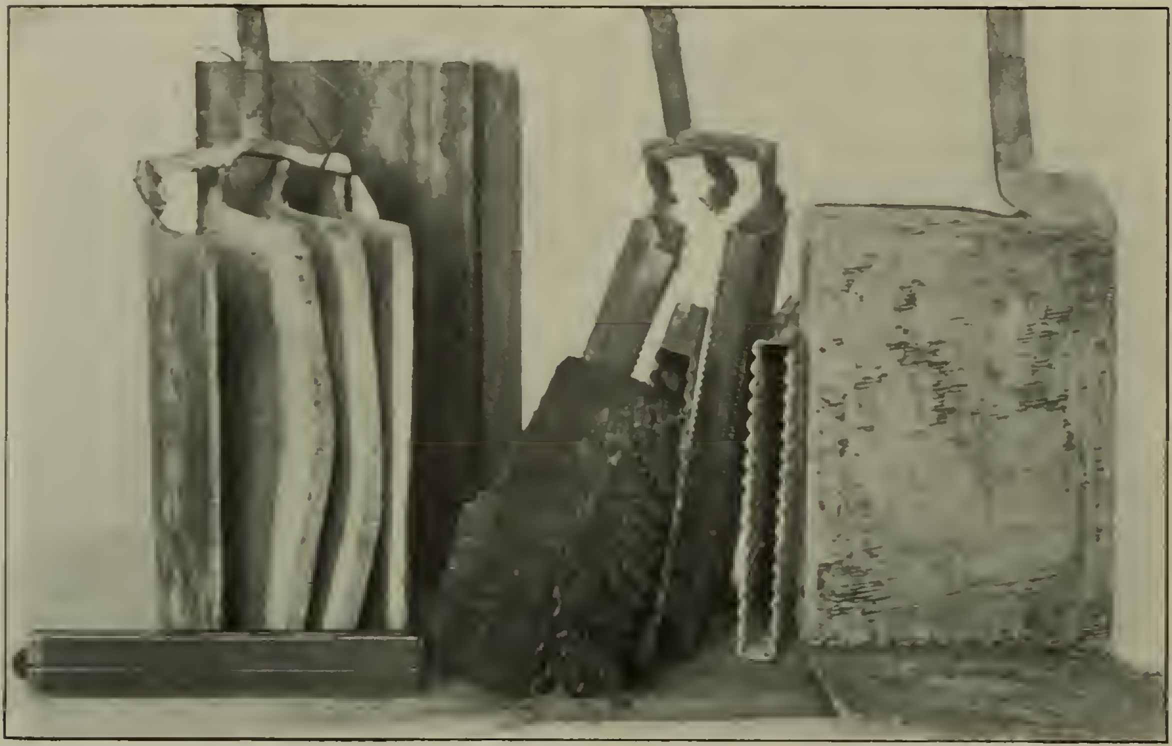
The gasoline and the steam vehicle were not slow in accepting the opportunity thus afforded. While not as quiet, clean, simple, and reliable as the electric, they could go anywhere, and at speeds which the horse could not approach. Moreover, the cost per mile gave every promise of being far below anything before possible. The possibilities in the way of long-distance touring, without regard to base, began to attract widespread popular interest. Communication between distant points not on a railroad became possible,—a thing entirely impossible before in anything like quick time.

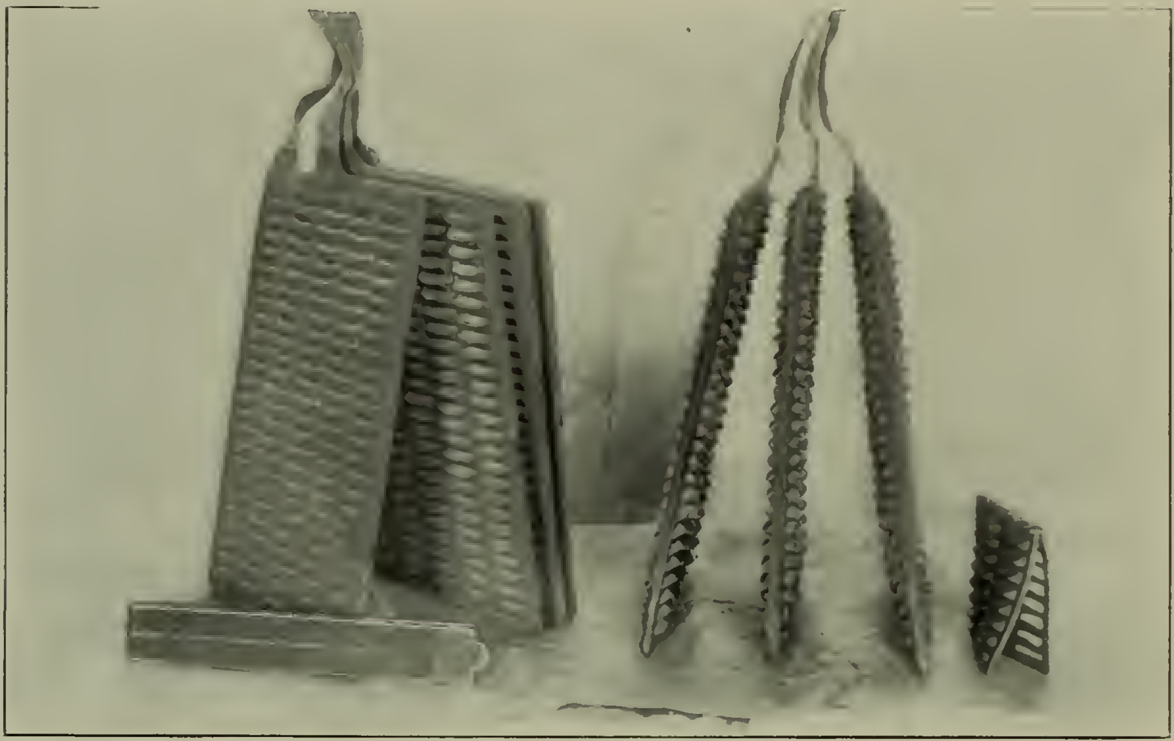
The supremacy of the electric vehicle thus began to be assailed. While unapproachable still in cleanliness, simplicity, and reliability, it was forced to recognize that it could not remain supreme on account of these advantages alone.

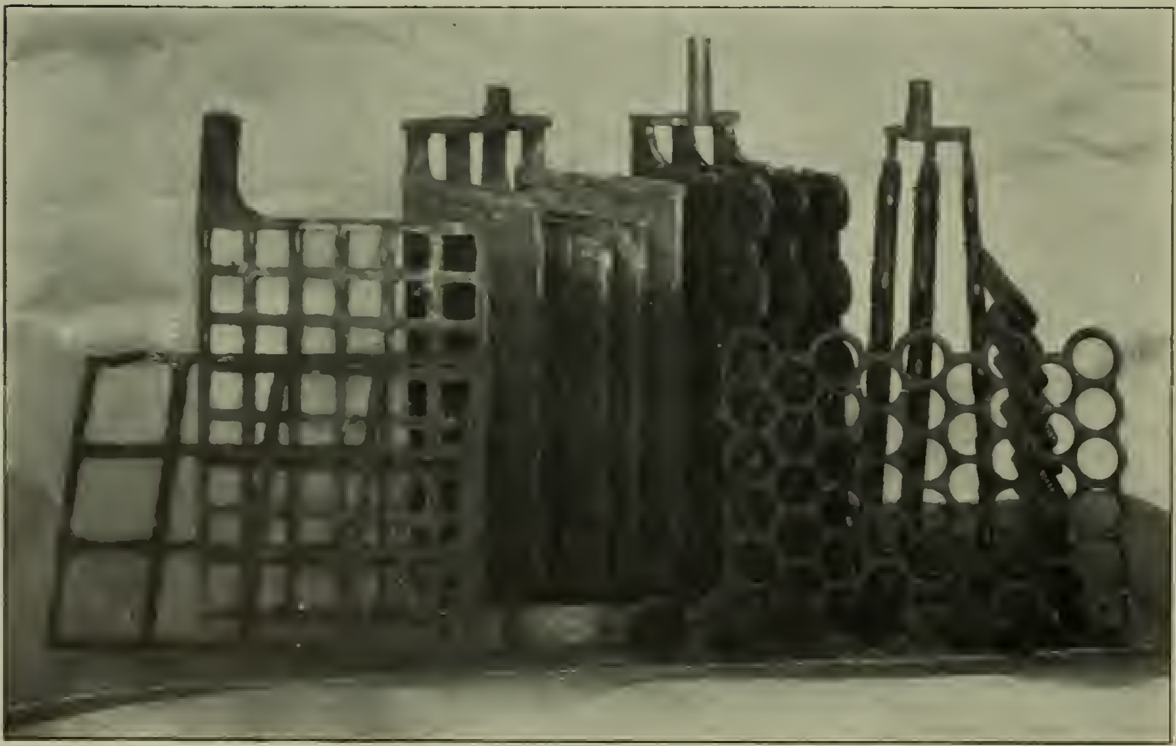
It is worth while here to record the attempts made by electric vehicle builders to maintain the supremacy of their product. The company with which the writer was connected decided to build an electric carriage for long-distance running and touring. The writer designed the vehicle, which is shown in Fig. 14, and the Electric Storage Battery Co., of Philadelphia, produced the battery, which had the highest capacity then possible with a respectable length of life.

As will be noted, it had a long body to accommodate the large battery. The passenger-carrying space was a small percentage of the entire floor area, although this could easily have been improved by carrying the batteries below the body. The battery capacity was approximately 210 ampere hours at 86 volts, and a Westinghouse 20-ampere, 85-volt motor was used, pivoted on the rear axle, and driving each rear wheel by pinion and gear. The vehicle weighed in

FIG. 7. THE FIRST REGULAR ELECTRIC PLEASURE CARRIAGE TO BE BUILT IN QUANTITY. BUILT IN 1897 BY THE POPE MANUFACTURING COMPANY, HARTFORD







FIGS. 8, 9 AND 10.—SPECIMENS OF STORAGE BATTERY PLATES AFTER USE IN ELECTRIC VEHICLES. THEY SHOW THE DEVELOPMENT DURING 1898-9

the neighbourhood of 2100 pounds.

Its first trip was from Philadelphia to Atlantic City, a distance of about 75 miles, and was easily made at an average speed of between 12 and 13 miles an hour on one charge. The idea had been that if the vehicle could make 100 miles on a single charge, it would be enough for practical purposes. This was considered a satisfactory day's tour in those days and the speed was very nearly up to what the gasoline and steam vehicles would average.

After arriving at Atlantic City, arrangements were made to try for a full hundred miles. The writer and J. B. Entz, chief engineer of the Electric Storage Battery Co., had charge of the affair, and it was arranged with three reputable bicyclers, who had approved cyclometers on their bicycles, to ride 50 miles out on the road to Philadelphia and mark the 50-mile point.

Two hours after they had set out, the electric was started, the signatures of several people being secured as witnesses. The 50-mile mark was reached soon after the bicyclers had arrived and marked it. Their signatures were secured and the return to Atlantic City started immediately. It was reached in due time, the batteries still having a good voltage. The signatures of the witnesses of the start were again taken and positive proof of the accomplishment of the distance secured. The average speed was something under 12 miles per hour.

It was probably the first time the distance had been made on one charge by an electric machine. The roads, however, were extremely good most of the distance, and the grades of no moment, and, while the distance had been accomplished, it was not representative of regular touring conditions, so in reality it amounted to little else than a last expiring gasp of the electric to hold its own in the long-distance field.

A few months later on, however, the writer made the run from Philadelphia to New York in the same machine, on a single charge, at an average speed of between 11 and 12 miles an hour, a feat which, it is believed, an electric has not equalled since,—probably because no one has seen fit to be foolish enough to undertake it.

Up to about two years ago the electric and the prime mover powers preserved about this status in relation to each other. Neither was able to encroach to any extent upon the field of the other. Each had improved rapidly in noiselessness, speed, and certainty. The advent of the

Edison battery, which was thought to be an important event in the development of the electric vehicle, served to temporarily accelerate interest in the electric and actually caused a few sporadic attempts to re-enter the long-distance touring field. But it was short-lived, for the immense superiority which the gasoline vehicle had attained by this time quickly returned the electric to its place.

During this period, the development of the electric vehicle was not standing still, however, although its improvements did not serve to materially check the progress of its competitors. The cab service and general livery service developed in New York City into one of the accepted forms of city transportation.

An immense central station and several branch stations were gradually established, which represented a vast invested interest. All over the country electric charging stations had become installed in the large cities, and expert attendance made available. Electrics of every conceivable form and type became common. The cab became a livery hansom or brougham of a highly specialized type, bearing but a small resemblance to the original of Morris & Salom. Being electrically and mechanically quite a high type of development on account of the severe service it operated under, it is worth while noting its essential features.

The battery,—the chief element in maintenance expense,—resolved itself into a full pasted positive and negative. The details of the plates, separators, jars, connectors, and trays were worked out very carefully and systematically, with long life and easy renewal the chief points. A system of battery loading and unloading apparatus was developed, adding materially to the chances the battery had of giving good performance. Every detail concerning the battery and its care came in for elaborate development and improvement until the station of the New York Transportation Co. became one of the most wonderful of all motor-vehicle developments up to that time.

In the case of the vehicle itself, it had increased in weight, size and strength to a degree which at first seems astonishing. Its batteries were larger, the motors were larger and of greater capacity, and the axles, wheels, tires, and running gear were larger, stronger, and heavier. Refinements tended toward greater weight, rather than lighter weight, because at the time lower maintenance expense was most easily accomplished in that way.

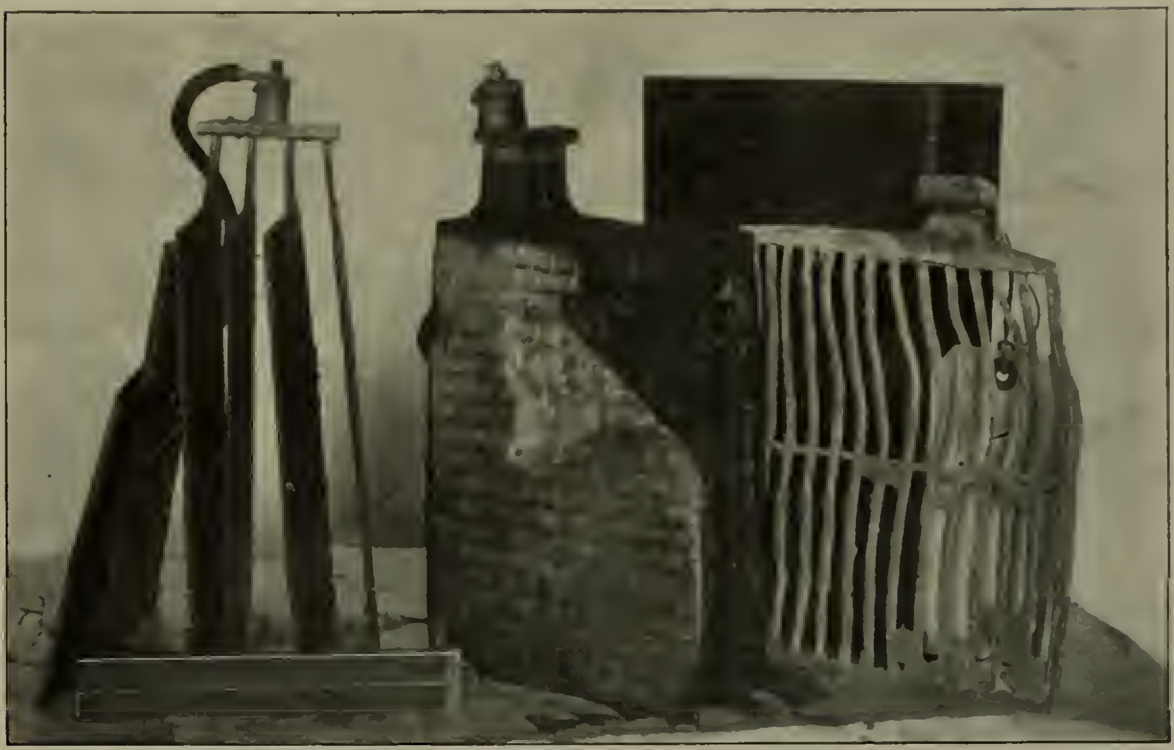


FIG. 11.—STORAGE BATTERY PLATES ALSO DEVELOPED DURING 1898-9

In such features as motor suspension, no material change had been made from the earlier types of Morris & Salom. The motors remained pivoted to the driving axle and suspended either from the body or from a tubular running gear, and drove through single-reduction spur pinion and gear. The motors themselves had been improved, being made with laminated field rings and pole pieces, and with improved brush holders, shaft lubrication and field-coil anchorage, making them markedly better than anything developed up to their time.

The tires, another important feature, had been made of endless solid rubber. Their life had been lengthened, making a considerable saving in the cost of maintenance. An effect which this improvement also brought about was a decrease in the tractive effort. With such heavy vehicles as the hansoms and broughams for livery use had become,—they weighed 5000 pounds,—the pneumatic tire caused serious loss, this of course appearing in the form of work done upon the tire, causing the latter to rapidly disintegrate. With the solid rubber tire this was overcome. Where a level tractive effort had been from 22 to 25 pounds per 1000, at 12 miles per hour speed, it had become 13 to 16 pounds per 1000. This of course had its effect in turn upon the batteries and motors. Discharge rates and the number of chargings a week were reduced, and motor heating effects were lessened.

In minor details, important and interesting, but impossible to deal with here, corresponding improvements were made, all tending to help each other and reduce difficulties and maintenance expense. A comparison of Figs. 5, 6, 15, 16 and 17 will show the evolution of these vehicles.

In the pleasure carriage, the improvements during this period, from 1899 to within two years ago, also showed the development of the electric vehicle as far from standing still. Perhaps the greatest advance, at any rate the one most difficult for the gasoline and the steam vehicles to equal, was in the direction of noiselessness, elegance, and smoothness of running. Speed and general reliability also came in for improvement.

A small piano-box runabout known as the "Pope-Waverly," which appeared during this period, attracted a great amount of attention because of its being the first motor vehicle to be all but absolutely noiseless. Unless an effort were actually made to

FIG. 12.—ANOTHER TYPE OF STORAGE CELL FORMERLY IN USE IN ELECTRIC AUTOMOBILES

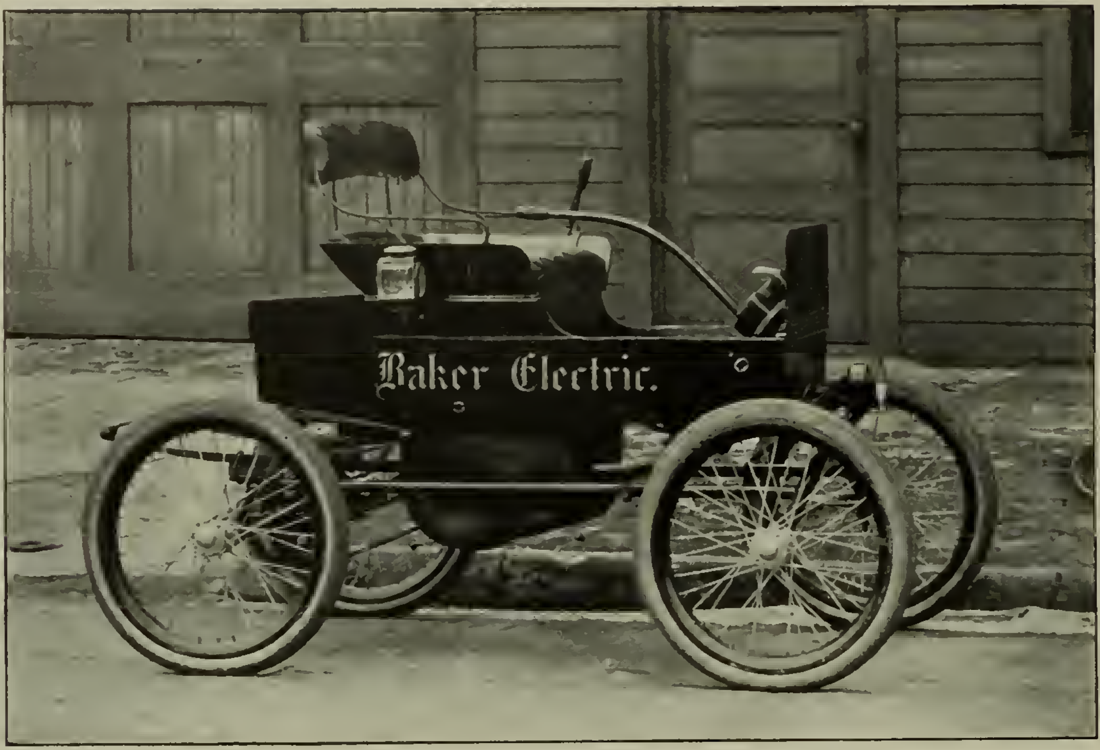


FIG. 13.—A RUNABOUT BUILT IN 1899 BY THE BAKER MOTOR VEHICLE COMPANY, CLEVELAND, OHIO. IT WAS THE LIGHTEST ELECTRIC AUTOMOBILE UP TO ITS TIME

detect its noise, it appeared to be entirely silent when under way.

This degree of noiselessness was secured by the use of the so-called "herring-bone" gear teeth in the motor pinion and driving gear, instead of ordinary spur teeth. The teeth were cut at an angle of approximately 45 degrees across the face of the gears, which were made in two rings, one cut right-handed and one left-handed, so as to balance end thrust.

Another important development which appeared at this time was a marked increase in speed. Where 12 miles an hour had been usual, 15 miles an hour was becoming the rule in pleasure carriages. This was of course due to the influence of the gasoline car, which made 12 miles an hour on the level and 8 on an ordinary grade look ridiculous. This higher speed tendency spread to all classes of vehicles, even the largest landaus, and broughams coming finally to it. It meant, of course, higher battery discharge rates and larger motor capacity, but fortunately these were forthcoming from the battery and motor builders, although not without application of much pressure, since both the latter had at this time only just about awakened to the commercial possibilities of the electric automobile.

Another feature of development was the standardizing of 40 miles on one charge, and this over ordinary roads and grades. Before the end of 1902, an electric vehicle which would not run 40 miles on one charge was considered out of it.

This feature also spread to all classes of pleasure vehicles, forty miles being usually a safe margin for a day's work for almost all carriages. It permitted a carriage to be independent of its base all day, and unless upon some extraordinary undertaking, the charging need only be done during the night.

This feature, while at first very difficult of attainment, and considered by the battery builder as nothing short of unreasonable, really acted as a help to the storage battery. Once the mechanical construction had been reduced to where a high enough percentage of the total weight was in the battery, and a large battery had come to be acceptable, it meant that the total number of chargings a season was materially reduced. Since it was principally the charging which really washed off the active material, anything tending to reduce the number of times it occurred was an advantage. Thus it proved, and the writer considers himself safe in saying that this one feature has been more potent in reducing battery troubles than anything else that has been done to the battery since the beginning.

Another one of the important advances worth noting was the marked improvement in motor characteristics. It had dawned upon the large electrical engineering companies that possibly there was something in the automobile movement after all. Once impressed with this fact, they began directing the attention of their engineering talent to this subject. It was not long before it was discoved that while a certain motor might be lighter than another motor, yet its speed-torque characteristics were such that, for a given service, the heavier motor more than paid. In other words, adding weight to the motor judiciously could be made to give the same effect as removing weight elsewhere.

The result was the appearance of the specialized automobile motor, a very economical and superior piece of apparatus. While it had been slow in coming, it had made up for its delay by being probably the most durable, long-lived, fool-proof, and appropriate piece of automobile apparatus in existence. Had it had for a companion an electric generating device as satisfactory as itself, this story of the struggle of the electric automobile to hold its own could have ended here.

The attainment of a very fair state of reliability of the several important organs of the electric vehicle had the effect of quickly bringing out all manner of business vehicles, such as

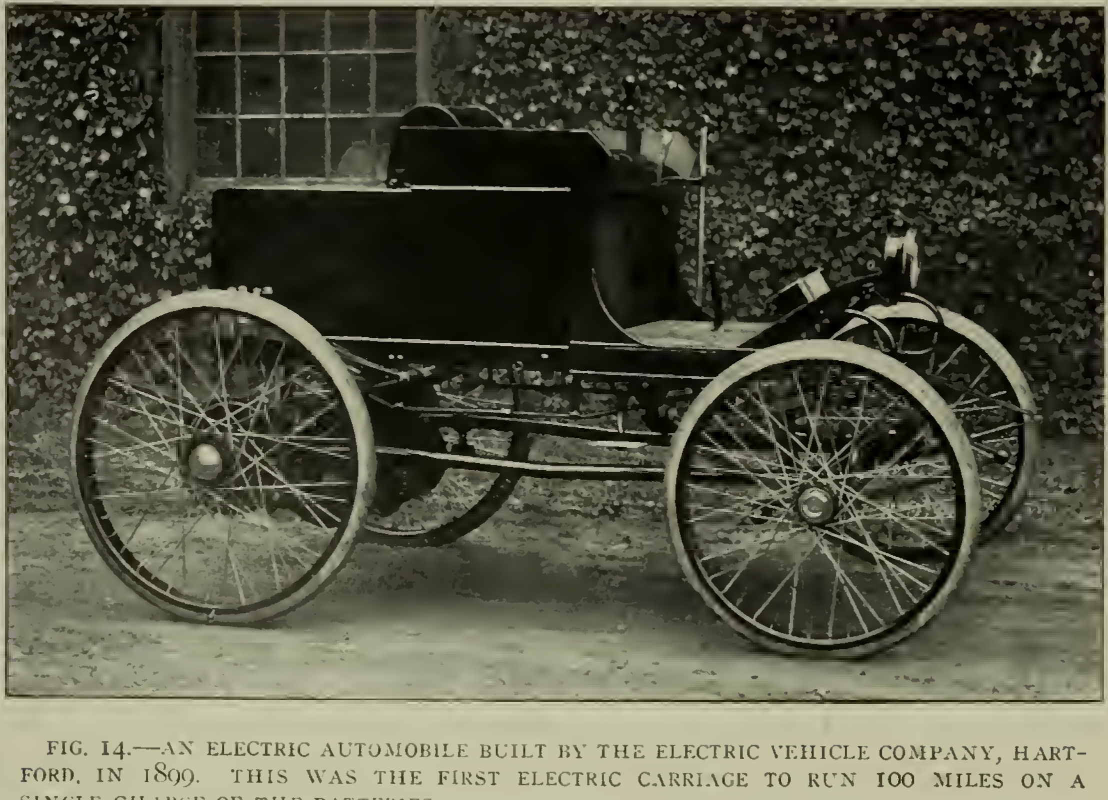


FIG. 14.—AN ELECTRIC AUTOMOBILE BUILT BY THE ELECTRIC VEHICLE COMPANY, HARTFORD, IN 1899. THIS WAS THE FIRST ELECTRIC CARRIAGE TO RUN 100 MILES ON A SINGLE CHARGE OF THE BATTERIES

wagons and trucks. Almost before one's eyes, electric wagons and trucks of every conceivable variety appeared upon the streets of our large cities.

In the main they were similar in general characteristics to the pleasure carriages, and were equipped with two motors, each pivoted to the rear driving axle and connected one to each driving wheel by spur pinion and gear. No running gear such as reaches or perches was used, but instead, the sill of the wagon or truck, or a frame the equivalent of the sill, had all springs and axle-supporting devices directly fastened to it. The batteries came to be universally carried below the bodies, leaving the body proper unencumbered for merchandise. These batteries were usually of the pasted type, precisely the same as used in pleasure carriages at the time, as no specialized battery for commercial wagon purposes existed.

The different speeds were almost universally obtained by dividing the batteries into groups and connecting these groups and the two motors in multiple series. Four speeds were the usual number, and the circuit was broken completely between each. The cost of operation of these early trucks was found to be higher than was expected. Mechanical details which were fairly satisfactory on pleasure carriages, were found to be entirely inadequate in the severe service of the commercial wagon.

Tires gave continual trouble, in most cases being of insufficient size for the loads; but rubber tires for heavy commercial service were not entirely understood, and experience was necessary. Motors were fairly satisfactory where adequate capacity was provided. It required a deal of experience, however, before the temptation to put small, light motors on heavy wagons could be resisted.

The battery question was of course the most difficult one. In commercial service it seemed to be all but impossible to get competent attendance at the stables of the owners of the vehicles, and at one time this difficulty threatened to put a stop to the development of the electric business wagon. It was for this reason that one company in New York established a large station and performed the maintenance service on its customers' vehicles. Competent attendance was then assured the batteries, and also the mechanical parts. This arrangement simplified the difficulty immensely. Skilled labour was gradually developed, and owners of large numbers of vehicles were able to give them decent attendance.

(To be continued.)

FIGS. 15, 16 AND 17.—THE DEVELOPMENT OF THE LIVERY CARRIAGE. FIGS. 16 AND 17, DURING 1900; FIG. 18, THE MODERN TYPE

Electricity on the Cunard Turbine Steamship "Carmania."

IN a ship of the size of the latest addition to the Cunard Steamship Company's fleet, the turbine steamer "Carmania,"—31,000 tons displacement,—and with so large a passenger capacity, the electric installation constitutes an important feature.

As told in a comprehensive description of the new ship in London "Engineering," the generating plant includes four generating sets, each giving an output of 75 KW. when running at 450 revolutions per minute. The large main switchboard has thirty-six circuits,—sixteen for the lighting of the ship; ten for thermo tanks and ventilating fans; three for electric heaters; three for turbine lifting gear in the engine room; two for boat hoists; one for galley machinery, and one for the searchlight projector.

The lighting installation is arranged on the double-wire system. The mains of each circuit are led from the switchboard to a double-pole fuse junction box, which again supplies two, three, or four-way switch and fuse boxes, each in their turn feeding six, eight, or ten-way double-pole distributing boxes. Feeders are led from the distributing boxes to small porcelain extension boxes, whence branch wires are connected up to the lamps. Not more than three lamps are taken from each feeder. There are in all about 2650 lights.

The mains of each power circuit are led from the switchboard to a double-pole fuse junction box, with feeders thence to each motor.

Electric heaters have been largely adopted. The first-class dining-saloon is heated by four large ornamental heaters, two placed at the fore end of the saloon and two at the after end. Each of these takes a current of about 20 amperes. In the writing-room there are two similar, but slightly smaller, heaters. Six special staterooms on the promenade deck are each fitted with two heaters, while five smaller rooms are supplied with one each. These heaters each take a current of 7 amperes. Each first-class bath room on the same deck has a small wall-heater placed near the door. It takes a current of about 5 amperes.

Motors are used for various purposes. In the engine room there are three electric motors, each of 18 brake H. P., located above the turbines, for lifting the turbine cases and rotors. On the boat deck there are two electric winches with warping drums for lifting the ship's boats. In the storerooms on the lower deck three electric hoists are installed for raising supplies to galleys and pantries. One 5-cwt. hoist of 3.5 brake H. P., and one 3-cwt. hoist of 1.56 H. P. supply the first-class galley, while a similar one is located in the third-class galley and pantry. These motors with their controllers are all on the lower deck. In addition to this a 2-cwt. coal hoist is placed in one of the vent shafts from the stokehold, to raise coal for the first-class galley. In the mail sorting room, which is aft on the upper deck, a 4-H. P. motor, designed for lifting 5 cwt. at 150 feet per minute, is employed for lifting the mails to the mail room on the orlop deck.

The electrical equipment of the galleys and pantries includes the following:—One dough mixer for the bakehouse; one roaster for the first-class galley; one dish washer for the first, second, and third-class pantries; one grid in the first and second-class pantries; the bridge-deck service pantry; the promenade-deck service pantry; the first-class smoke-room bar; and the officers' pantry. In addition to these, there are three knife cleaners. The first and second-class barbers' shops are provided with an electric hair brusher, and a one-gallon electrically heated hot-water urn.

Small table fans are provided for the chief engineer's cabin, engineers' mess, doctor's and first-class barber's shops.

As regards the telephone service, there is in the wheel house a telephone communicating with the engine room, the look-out at the forecastle, and the steering gear at the after end of the shelter deck. The telephone at the forecastle is of a portable type, with a hose-coupling connection through the deck, so that the telephone can be removed when not in use, while the one at the after end of the shelter deck is of a pillar type. All the telephones are of the loud-speaking Admiralty pattern. In addition to the above, there are intercommunication telephones fitted in the staterooms of the captain, chief steward, chief engineer, and in the lower steering compartment.

For cabin bells there are twenty-two indicators throughout the ship, giving a total of about 421 groups of communications. The bridge and shelter deck indicators are grouped up to a special indicator, so as to ensure the answering of a call at night time from any of the staterooms connected to those indicators, while the drawing room, writing-room, and entrance to the promenade deck are grouped up to the same indicators.

The electric illumination is on a lavish scale, and a special feature is the introduction throughout the first and second-class corridors of toilet indicator lights. Similar prominent lights are placed at the doctor's, steward's, and purser's rooms, etc. The navigating light, telegraphs, and compass rooms are also electrically lighted. There are also twelve cargo-reflectors, each of six 16-candle-power lamps, two for each hold. The masthead and bow lights have a signal indicator placed in the wheel house.

Throughout the ship there is a system of warning bells in connection with the Stone-Lloyd system of operating bulkhead doors. These bells are fitted near to each door. In the wheel house there is an indicator board showing every door, and as the doors close, the circuits in connection with each are cut in, and the lamps, corresponding to each door, are lighted up to show that the operation has been successfully carried out.

An automatic electric whistle gear is fitted to the forward funnel, and has three switches on the bridge: one on the port side, one on the starboard side, and one in the centre.

A submarine signaling apparatus, wireless telegraphy installation, and various other electrical devices have been fitted, making the electrical installations most complete.

Referring to the article entitled "A Typical Berkshire Hydro-Electric Plant," in our February number, Mr. James F. Bush, treasurer of the Woronoco Paper Company, whose plant is the one under consideration, informs us that while the construction work and the general layout of the dam, penstock, and forebay was done by him, the selection of the generators and the general electrical installation were under the care of Mr. A. R. Bush, at that time of the General Electric Company, of Schenectady, and now second vice-president of the Union Bag & Paper Company. The work was performed under contract with the General Electric Company. We make this correction most cheerfully, and regret only that credit for the electrical part of the work was not originally given to Mr. A. R. Bush, as it should have been.

All postal cars of the Union Pacific Railroad are to be lighted by electricity under the axle-generator system.

Niagara Underground

By ALTON D. ADAMS

TUNNELS, pipe lines and canals that are opening to suck down Niagara water, have a greater capacity than the American channel to the Falls. Five of these openings through the cliffs now connect the upper river with Niagara Gorge. As these artificial waterways are underground, their dimensions cannot be readily observed, save in the case of the canal, and even there the depth is not generally known.

So great is the combined cross-section of the conduits that lead to and from the turbine wheels in the power plants about Niagara, that if all the water that now goes over the American Falls were turned into them, they would not run more than half full. Three tunnels, one pipe line, and one canal are now completed from the upper river to points below the Falls, but at present they are carrying only a small fraction of the water that they are capable of delivering. No great diminution of the flow over the American Falls can therefore be noted at this time, but when these five artificial channels are running full there will be another story.

One of the three tunnels and also the canal are on the New York side of Niagara River, and the other two tunnels and the pipe line are on the Canadian side. The tunnel that pierces the cliffs along the New York bank, is designed to carry 8600 cubic feet of water per second to the lower river. On the Canadian side, one tunnel is to receive 10,000 cubic feet, and the other 11,200 cubic feet, per second, from turbine wheels beneath the power houses.

The steel pipe line running from the Dufferin Islands at the head of the upper rapids to the Gorge below the Falls, has a delivery capacity of 4000 cubic feet of water per second, with an estimated friction loss of 15 feet in head, but this rate of discharge may of course be increased, if a greater loss of head to overcome friction is permitted. For the canal, the capacity to carry water around the Falls is now put at 7700 cubic feet per second, under certain desirable conditions of operation, but this does not represent its possible ultimate rate of discharge.

A summary of the above figures shows that the three tunnels, one canal, and one pipe line, now constructed to divert water above Niagara Falls and discharge it into the lower river, have a combined capacity sufficient to pass more than 40,300 cubic feet of water per second. With mean Lake Erie level at 572.86 feet above tidewater, the total discharge of Niagara River amounts to 222,400 cubic feet of water per second, and when the lake level drops to an elevation 570.25 feet above tidewater, the corresponding discharge of the river is 165,340 cubic feet per second, according to the report of the Secretary of War for the year 1900.

The capacity of the five artificial conduits about the Falls, as above named, amounts to 18 per cent. of the mean, and to 24 per cent. of the average, discharge rate of Niagara River over both the American and the Horseshoe Falls. It is variously estimated that from 10 to 20 per cent. of the entire volume of Niagara water goes over the American Falls. It is quite certain, however, that the smaller of these percentages is the more nearly correct, for the channel between the New York bank of the river and Goat Island has at its head only about 15 per cent. of the total width of the stream, is much more shallow than the Canadian channel, and slopes less by 6 feet than the latter between the upper line of breakers and the crest of the Falls.

As 10 per cent. of the mean discharge of the river is 22,240 cubic feet per second, and the same percentage of the minimum discharge is 16,534 cubic feet, it seems improbable that the water flowing down the channel between the New York bank and Goat Island, would more than half fill the three tunnels, the canal, and the pipe line above named. By comparing the combined cross-sections of the tunnels, pipe line, and canal, with what is known as to the dimensions of the American channel, the conclusion just reached is reinforced.

Each of the three tunnels is of the horseshoe type with slightly concave floor and nearly semi-circular roof. The single tunnel on the New York side of the Falls has a center height of 21 feet, a maximum width of 18 feet 10 inches, and a bottom width of 16 feet. On the Canadian side, one of the two tunnels is 25 feet high along the center line, 19 feet in greatest width, and about 16 feet wide at the bottom. The other tunnel there has a corresponding height of 25½ feet, a maximum width of 35 feet, and a bottom width of about 32 feet. The foregoing dimensions give the three tunnels a combined area in cross-section of about 1450 square feet.

As the line of steel pipe on the Canadian bank has an internal diameter of 18 feet, its area in cross-section is 254 square feet. For the canal around the American Falls, the uniform width is 100 feet from its head above the rapids to the basin on the cliff below the cataract. The head of this canal at Port Day has a depth of 14 feet of water, but the depth along its entire length is not generally known. For this canal the cross-section may be taken as $100 \times 14 = 1400$ square feet. Adding the figures for the tunnels, the pipe line, and the canal, shows their combined cross-section to be 3104 square feet, approximately.

The cross-section of the water flowing in the American channel between the New York bank and Goat Island varies at different points with the current velocity, but may be approximately determined. About 600 feet below the head of Goat Island, the American channel shrinks to a width of about 340 feet, and it seems probable that the average depth of water along this width is more than 10 feet, which would give the stream an area in cross-section of 3400 square feet.

Passing on down the channel to the crest of the American Falls, the average depth there is thought to be not more than 3 feet, and the length of the crest line is less than 1000 feet, so that the cross-section of the falling water probably does not reach 3000 square feet.

If these figures are substantially correct, as seems most probable, it is to be noted that the cross-section of the stream in the American channel is just about equal to the combined sectional area of the three tunnels,

the canal and the pipe line. But this approximate equality of cross-section does not imply equality of discharge capacity, for the calculated velocity in the tunnels and the pipe line is much higher than the average velocity of the river water between Goat Island and the New York bank.

From the head of Goat Island to the crest of the American Falls, the rapids carry the water down about 48 feet in a length of about 2400, or 20 feet of fall per 1000 feet of length. But the bed of this part of the river channel is very broken, and most of the descent is made over a series of cascades with nearly level stretches in between. Hence, the resulting velocity of the water is much less than it would be in a smooth channel of equal length and total descent and uniform slope. It is for this reason that the five, smooth, artificial waterways above named have a capacity to carry fully twice the volume of water that normally goes down the American channel, though their slope is less, and their combined cross-section is only about equal to that of the water in this channel.

In the tunnel on the New York side of the Falls, the slope from the upper toward the lower river is 7 feet per 1000 feet of length, and this is also the slope in one of the tunnels on the Canadian side. The 18-foot pipe line on that side of the river drops 28 feet in a length of 6180, or about 4½ feet per 1000 of length.

In the above comparisons between the total sectional area of the five artificial watercourses and the section of the stream in the American channel, the normal discharge rate of 222,400 cubic feet per second for Niagara River has been assumed. At lower rates, the ratio of the combined capacity of the tunnels, pipe line, and canal to the flow of water in the American channel would be still greater. The average depth of water along the crest of the American Falls was thus taken at 3 feet, but during a part of the winter of 1903-1904, ice cakes only 18 inches thick would catch on the rack shelf at the crest of the Falls before going over.

On February 14, 1896, the bed of the cascades just above the Three Sister Islands was almost bare, and no water was then going over the American Falls between Goat Island and Luna Island, so that the Cave of the Winds was exposed to view.

The Marconi Wireless Telegraph Company has opened a new station at Seagate, Coney Island, for communication with ocean steamers. It has a transmitting range of 200 miles.

A Model Electrical Equipment

THE LOUISVILLE & NASHVILLE RAILROAD SHOPS AT SOUTH LOUISVILLE, KY.

By A. G. WESSLING

In the new shops of the Louisville & Nashville Railroad Company, at South Louisville, Ky., electricity has been applied to manufacturing purposes, with eminently practical results.

A railroad shop of this kind includes at least a dozen distinct lines of manufacturing, every one of which is a good-sized unit. All these units must be efficiently operated, and their various products finally brought together and assembled into fer tables lies the largest building of the group. It has a length of 1000 feet, and includes under one roof, the boiler shop, the general machine shop, and the erecting shop. The south bay of this building is divided into forty sections, and every section has a track connecting with the transfer table. Eleven of these sections are in the boiler shop, which is separated from the erecting shop by a brick wall twelve feet high.

The erecting floor is covered by

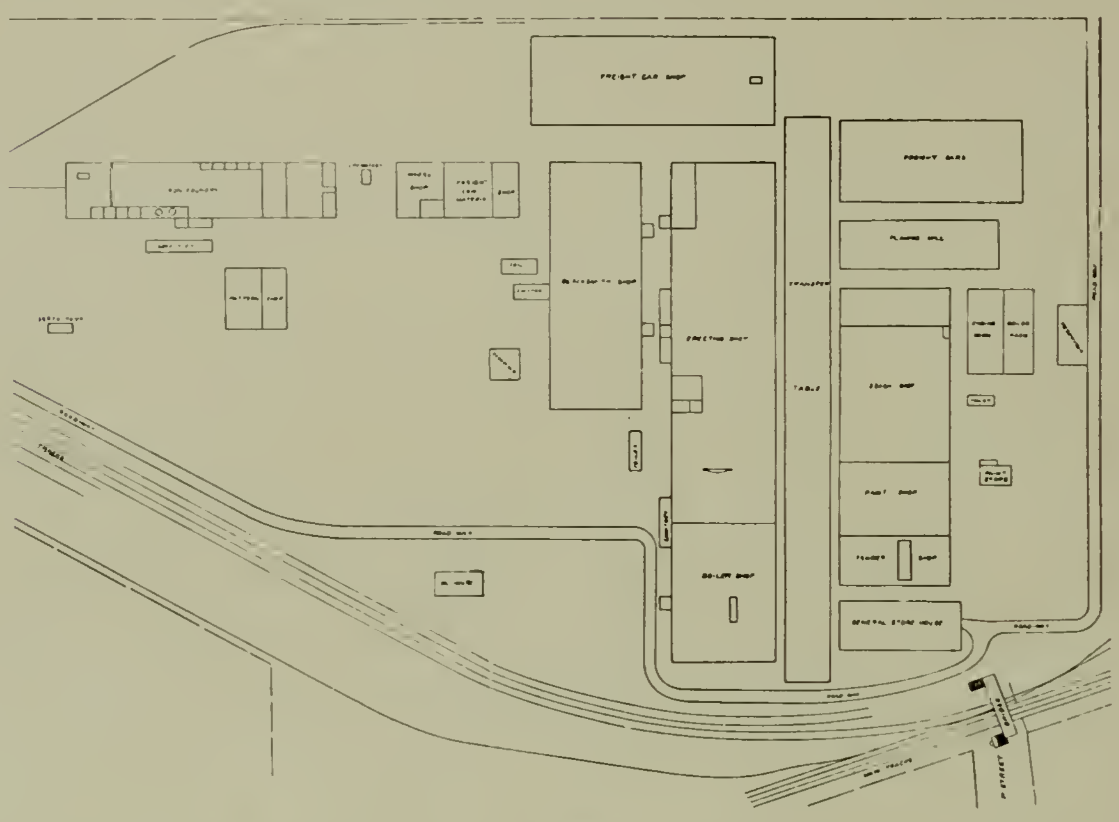


FIG. 1.—GROUND PLAN, SHOWING THE ARRANGEMENT OF BUILDINGS OF THE LOUISVILLE & NASHVILLE RAILROAD SHOPS. THE MOTOR-DRIVEN TRANSFER TABLE IS SHOWN IN THE LOWER RIGHT-HAND CORNER

railway rolling stock in the shape of freight cars, passenger coaches, and locomotives. How this is accomplished at the South Louisville shops, as far as may be done by the arrangements of the buildings, is shown in the ground plan, Fig. 1.

A transfer table, having a bridge 100 feet long and a transverse travel of 1050 feet, is the center about which the buildings are grouped, and serves as the connecting link to bind the various departments together. The bridge is operated by a railway motor, capable of driving it at a speed of twelve miles per hour. By means of sliding clutches, the motor may be disconnected from the bridge drive, and connected to a drum to pull coaches and locomotives onto and off of the bridge.

Along the north side of the trans-

a 100-ton crane, provided with two trolleys, and capable of carrying the largest sized locomotives from any part of the erecting shop over the wall into the boiler shop. A 10-ton crane on a lower runway serves to carry the small parts. All these traveling cranes, of which there are eleven, built by the Niles-Bement-Pond Company, of New York, are motor driven.

In the machine shop, however, the most interesting applications of electric drive are found. Near the middle of the shop is a switchboard from which are controlled the various local feeders, and their connections to the mains running to the power house. Near the switchboard is located a Bullock three-wire multiple-voltage balancer, shown in Fig. 5, which divides the 240 volts supplied by the mains into

100-volt and 140-volt circuits. A third wire, in addition to the generating mains, serves to supply three different voltages, namely, 100, 140 and 240, to the motor-driven tools, which operate at variable speeds. These different voltages are applied successively to the motor armatures by means of a Bullock type-"Y" controller. Intermediate speeds, and speeds above the normal at 240 volts, are obtained by the use of shunt-field resistance.

Fig. 3 shows a 90-inch driving-wheel lathe, and Fig. 4 a 3-column radial drill, driven by Bullock variable-speed motors, as are also a number of heavy lathes and other tools of the kind common to all machine shops. The motors driving these large tools are rigidly connected to the machine, and the power is transmitted through gears. Such tools as are operated at constant speed are belted to a line shaft, which is driven by a belted motor.

In the boiler shop the large punches and shears are driven by individual compound-wound motors, which are belted to the tools. The slipping of the belt in starting, due to the unusually large inertia of this class of tools, allows the motor to start with much less current than would be required if the motors were geared, and the compounding of the fields has the same effect, as it increases the torque of the motor.

To the north of the machine shop, lie the forge shop and the wheel shop. In the forge shop, motors are used where possible, but, as nothing has been found thus far to displace steam hammers, the number of motors is not very large. In the wheel shop, the machine tools are all driven by a constant-speed type, and are belted to the countershafting. The whole shop is driven by a Bullock 60-H. P. motor.

To the north of the wheel shop lies the foundry, and electricity is used for all purposes to which it is applicable. The drop for breaking the scrap, the blowers for the cupolas, and the ventilating fans as well as the cranes, are all motor driven. The distance from the power house to the foundry is so great, that no other method of transmission could be considered.

Placed along the east side of the foundry is a runway supporting a traveling crane, and this runway passes along the side of the wheel shop, the end of the machine shop, and extends as far as the transfer table. The crane bridge is 40 feet long, thus giving excellent yard service to the various shops, and affording a very satisfactory method of transporting material from one department to another.

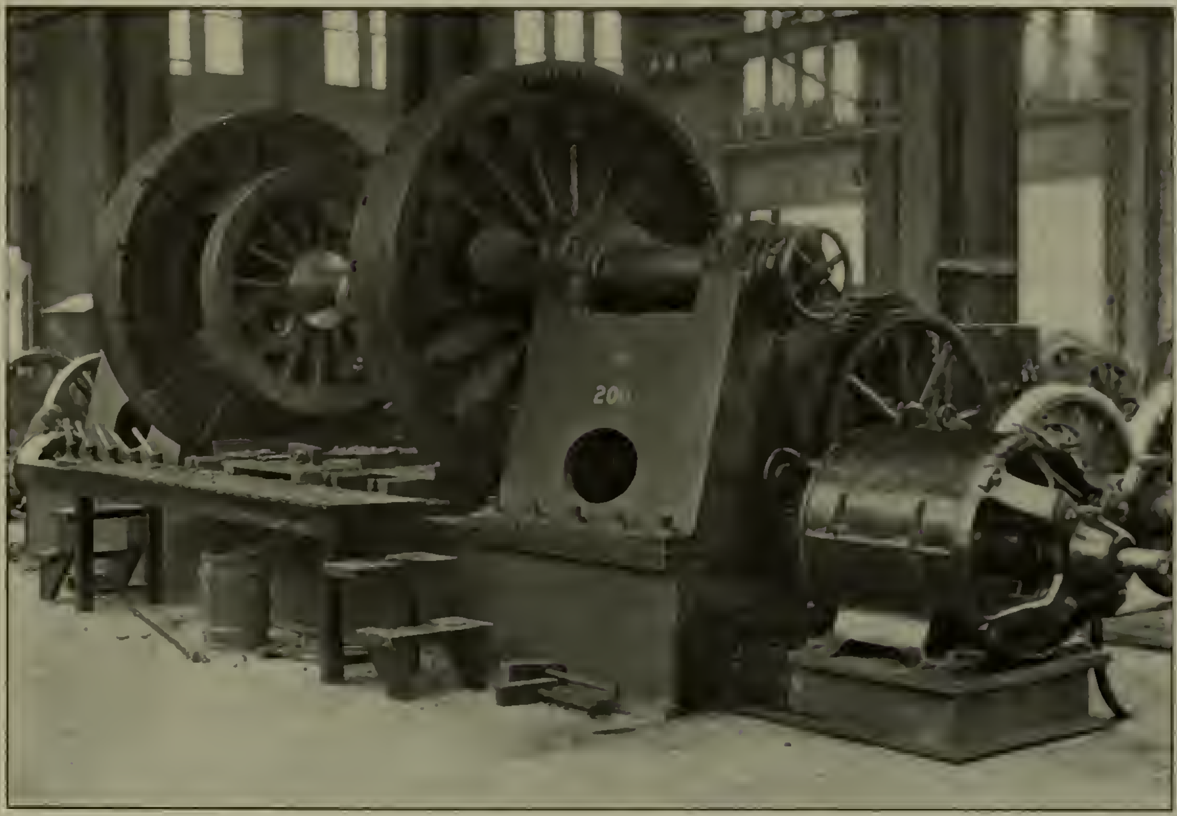


FIG. 3.—A 90-INCH DRIVING-WHEEL LATHE DRIVEN BY A BULLOCK VARIABLE-SPEED MOTOR BUILT AT THE ALLIS-CHALMERS CO.'S ELECTRICAL WORKS, CINCINNATI, O.

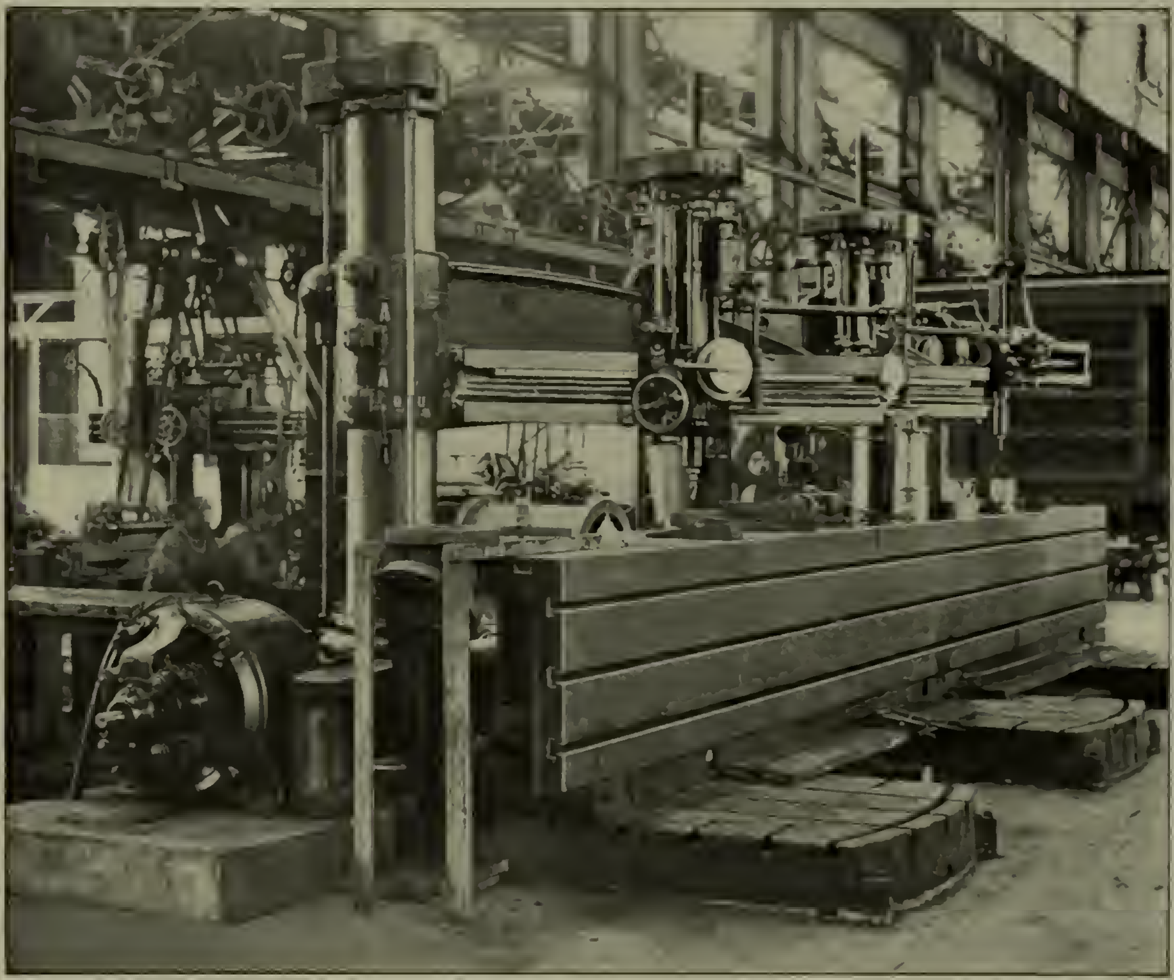


FIG. 4.—A THREE-COLUMN RADIAL DRILL. THIS ALSO IS DRIVEN BY A BULLOCK VARIABLE-SPEED MOTOR

In the wood shop the tools are operated at constant speed, and most of them are driven by belts from motor-driven line shafts.

The power house is located at the south of the group of buildings, where the handling of fuel and ashes can be done most conveniently.

The power equipment is shown in Fig. 4, and includes three 350-kilowatt, 250-volt Bullock generators direct connected to cross-compound engines built by the Buckeye Engine Company, of Salem, Ohio, and running at 175 revolutions per minute. Steam at 125 pounds pressure is supplied by a battery of boilers built by the Stirling Consolidated Boiler Company, of New York, and provided with mechanical stokers. The coal elevator is motor driven. In

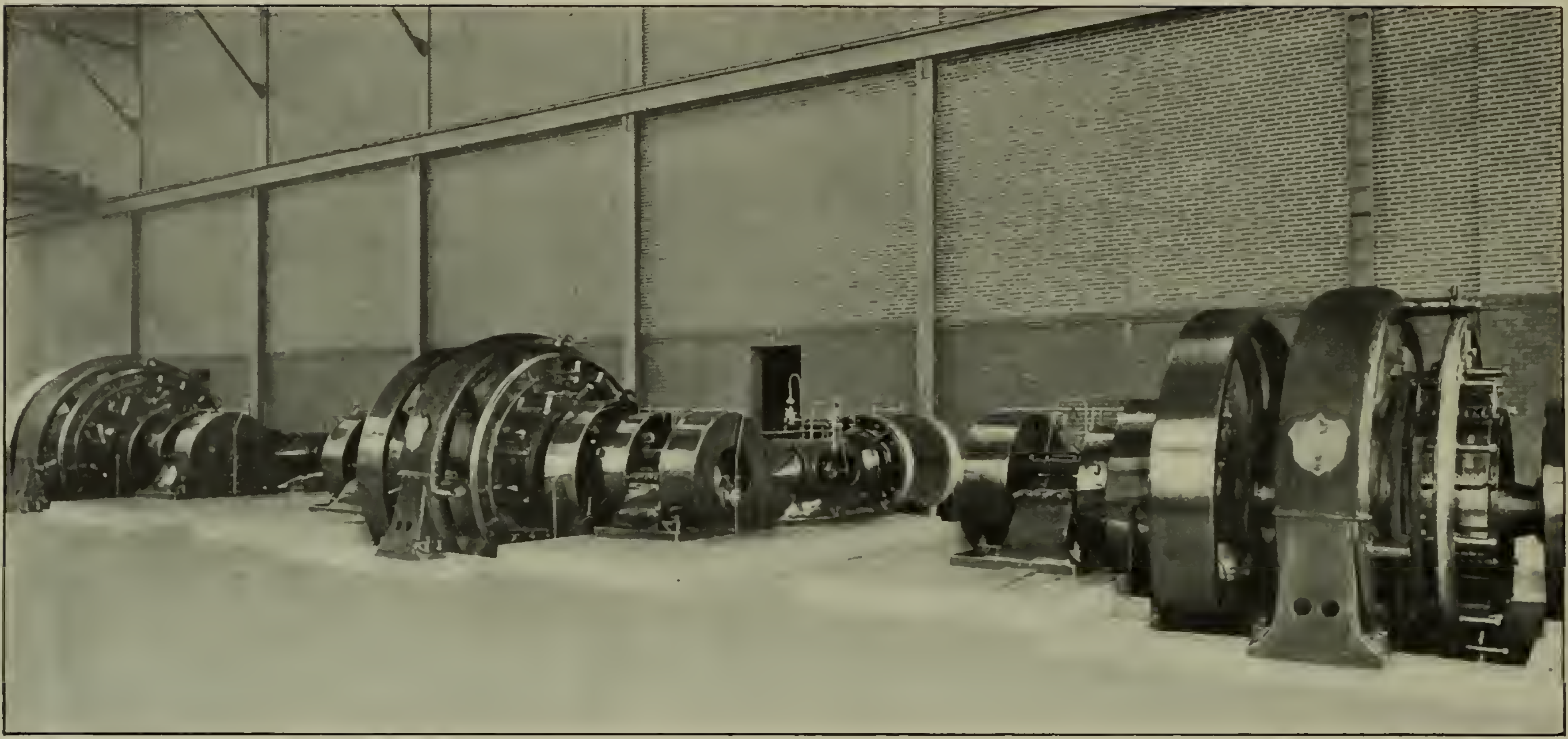


FIG. 4.—THE GENERATING EQUIPMENT FOR THE LOUISVILLE & NASHVILLE RAILROAD SHOPS CONSISTS OF THREE 350-KW. BULLOCK GENERATORS, DIRECT CONNECTED TO CROSS-COMPOUND ENGINES, BUILT BY THE BUCKEYE ENGINE COMPANY, SALEM, OHIO. ALL PIPING BETWEEN THE BOILERS AND ENGINES IS CARRIED BENEATH THE FLOOR

addition to the generators, the engine room contains a cross-compound, two-stage air compressor, and a 12 by 18 by 24 inch fire pump. The switchboard, built by the Western Electric Company, of Chicago, Ill., is equipped with flush-type instruments, made by the Western Electrical Instrument Company, of Newark, N. J., adding greatly to its appearance. All piping between engines and boilers is carried under the floor.

The perfection of details everywhere noticeable is due to the clear foresight and careful personal supervision of Theo. H. Curtis, superintendent of machinery.

Grinding Street Car Wheels

A METHOD of grinding street car wheels without removing them from the car, is described in a recent issue of "The Street Railway Journal." The machine for the work was designed by the superintendent of car equipment of the Public Service Corporation of New Jersey.

A pit is provided, over which the car is placed and within which are two emery grinding wheels so mounted as to operate on both wheels of a pair at once. The wheels are driven from a jack-shaft, which in turn is driven by a motor. An exhaust fan is bolted to the jack-shaft, which has suitable pipe connections and hoods to draw off the grinding debris. The motor wheels are revolved by the motor the same as when running on the track. Each grinding wheel is provided with independent longitudinal adjustment, the vertical adjustments being taken care of by means of screw-jacks, one being located under each end of the motor frame to support it during the grinding operation, the loose rails over the pit, of course, being removed. A pair of wheels can be ground into good shape in twenty minutes, including the time required for placing the car and removing it from over the pit.

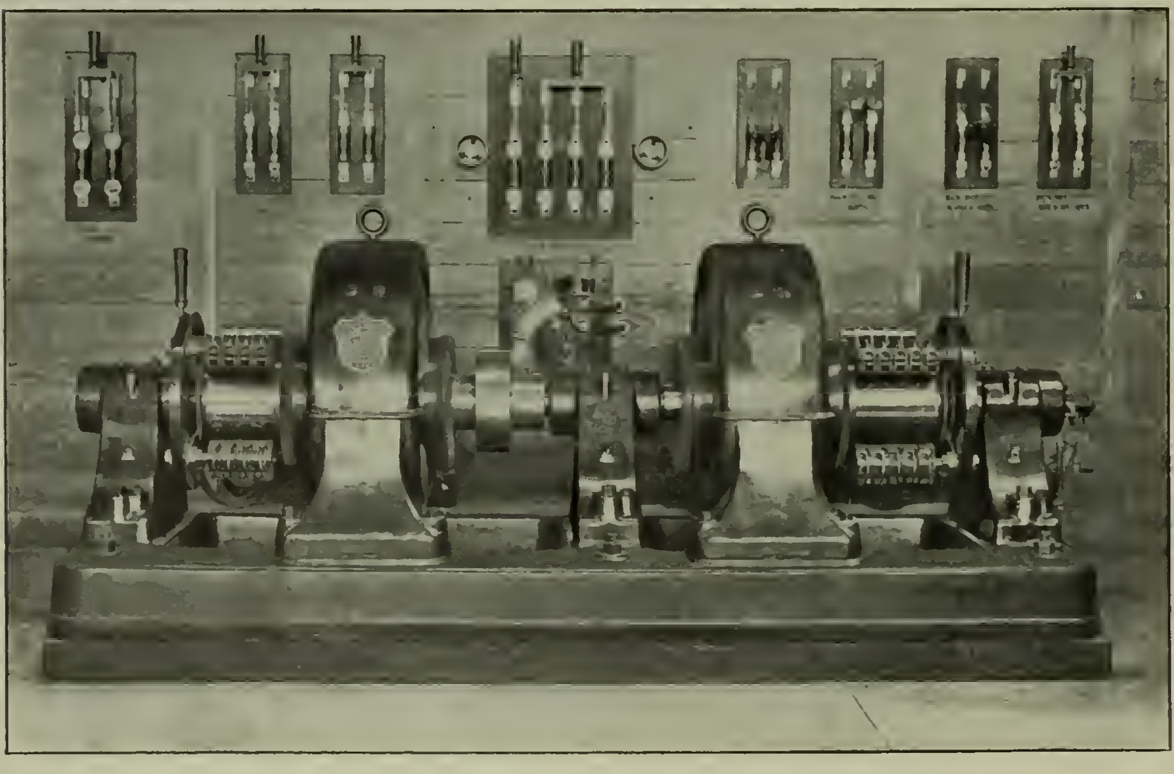


FIG. 5.—A BULLOCK THREE-WIRE MULTIPLE-VOLTAGE BALANCER DIVIDES THE 240 VOLTS SUPPLIED BY THE MAINS INTO 100 AND 140-VOLT CIRCUITS

According to Prof. James F. Kemp, in a recent address before the New York Academy of Sciences, of all the metals the most important which minister to the needs of daily life are the following, ranged as nearly as possible in the order of their usefulness:—Iron, copper, lead, zinc, silver, gold, tin, aluminium, platinum, manganese, chromium, quicksilver, antimony, arsenic and cobalt. The others are of very minor importance, although often indispensable for certain restricted uses. The United States have developed within a few years into the foremost producers of iron, copper, lead, coal, and, until recent years, of gold and silver; but with regard to gold, they have of late alternated in the leadership with the Transvaal and Australia, and in silver are now second to Mexico.

Electrical Experience in the Laundry

By H. S. KNOWLTON

IN describing the equipment of the E. and R. laundry, at Cambridge, Mass., in the July, 1905, issue of THE ELECTRICAL AGE, it was pointed out that the use of electricity in commercial laundry work was a radical departure from all previous practice, and the advantages of the cleaner and more flexible motor in comparison with dust-gathering belts and oily shafting were thoroughly presented. In the belief that the actual experience of such an industrial plant with electric power may be of interest, some of the results of 18 months' operation in the E. and R. installation are given here.

At present the plant is equipped with about thirty-five electric motors of the direct-current type, most of which are direct connected to the driven machines. The plant is lighted by about 200 16-candle-power incandescent lamps and five enclosed arcs, all operated on 125-volt circuits. All the flat-irons in the establishment are electrically heated, as are many of the heating rolls on the different machines, only the larger work of heating being performed by steam. The load upon the power plant is exceedingly steady and averages 200 amperes for electric heating, 200 amperes for power, and 100 amperes for lighting service.

During these 18 months, the company has learned much about the economy of electric power for laundry work over steam, and the equipment has been given ample opportunity to exhibit any inherent defects in its make-up. It is exceedingly gratifying to learn that the management are thoroughly satisfied with electricity after this extended trial, and would follow much the same general plan of installation if the establishment were to be built anew. Perhaps the most striking point is that the cost of operation has been found to be notably lower with electric power than with steam equipment, although many of the motors were found to be much too small for the exacting work in hand.

It has not been found that the use of electricity in this particular work has practically increased the laundry's production rate in comparison with steam, but the original generating plant of 50 KW. has been doubled in capacity by the addition of a new generator, built by the Crocker-Wheeler Co., of Ampere, N. J., and direct connected to an American-Ball horizontal, single-cylinder, high-speed engine, built by the American Engine Co., of Bound Brook, N. J., and a number of new motor-driven machines have been installed without any reduction in the laundry's rate of output. The growth of business caused the original Ball-Crocker-Wheeler set to be operated at 25 per cent. overload for about six months, and the outfit performed this duty without any sign of injurious overheating or sparking.

Although the load variations in some of the motor-driven machines are very severe, reversals occurring many times a minute, from full speed in one direction to full speed in the other, the current consumption of the plant, as a whole, is so even that the fuel consumption is not far from three pounds of coal per kilowatt-hour. This is an excellent record for an isolated plant. To heat the building, about 500 pounds of coal a day are required, and the difference between this figure and the total consumption gives the approximate fuel required in the operation of the establishment. The installation of the new unit provides a reserve, which the plant did not have at first, although there has been no serious trouble with the equipment in the direction of breakdowns. A new 125-H. P. boiler has also been added to the plant.

In very much the same way that the fuel consumption in a boiler plant depends upon the skill of the fireman, the rate of output of the electrically driven laundry depends more upon the skill of the employee than upon the motive power. The employees at the E. and R. laundry are highly in favour of the electrical equipment, especially the electric flat-irons, and it would be considered a hardship to go back to the old gas-heated ones.

It has not been found possible to use fewer employees with the electrical machinery, although the time required to shift belts and to change flat-irons has been cut out. The percentage of absent employees shows no variation from what would be expected in a steam laundry, although the conditions in the E. and R. installation are ideal from the standpoint of sanitation.

The principal troubles which have developed in the electrical equipment have been due to the smallness of some of the motors for the work in hand. At the time when the plant was installed, there had not been accumulated a sufficient body of experience to determine just what is the best size of motor for driving the various machines week in and week out. Consequently the power consumption of the plant was somewhat larger than it should have been, and some of the motor commutators gave trouble by becoming ridged and rough, necessitating frequent turning or sandpapering. Brush renewals were more frequent than was to be expected, but in general the motors have withstood the severe strains of the work very well.

Since larger motors have been installed, the power consumption has decreased and the results have become thoroughly satisfactory. Watson, Sprague, and Holtzer-Cabot motors are now in regular service. An improvement in the driving of extractors has been effected through the substitution of a 4-H. P., horizontal, compound-wound motor for the vertical shaft, 1½-H. P. machine originally installed. It was found extremely difficult to reduce the noise of the drive in the case of the vertical draft motor, as it could not well be oiled. The compound winding was introduced to enable the motor to deliver a more powerful starting torque.

Another point which has given some trouble is the inability of the electric flat-irons to stand much abuse. Although they are equipped with an automatic switch which reduces the current when the iron is placed on the holder, they have given trouble by burning out when the attendants have forgotten to remove the plug connection from the corresponding socket. The remedy has thus far consisted of a more rigid inspection by the supervising employees, every effort being made to reduce the leav-

ing of flat-irons in circuit when they are not in use.

The electric heaters on the presses and body-ironers have admirably withstood the constant operation to which they have been subjected. No trouble with the commutators or any other part of the equipment has resulted from the inevitable moisture of the laundry processes, and none of the goods have been injured by the electrical machinery. The latest extractor motors are of the enclosed type, to give additional protection.

Power is not metered by recording instruments, on account of the constancy of the load. This is so steady that the company does not consider it necessary even to take regular ammeter and voltmeter readings at the switchboard in the engine room, although the voltage is kept close to the proper value by occasional field rheostat adjustment when necessary. The steadiness of the lamps has been unaffected by the demands of the motor load.

The electrical equipment of the laundry has been utilized for the securing of new business through advertisements, a neatly printed pamphlet describing the various processes in the work of the laundry, and through the encouragement of visitors from all parts of the country and from abroad. Although the equipment of an electric laundry costs from three to five times that of a steam laundry, the E. and R. management feel that it is well worth the extra investment.

By the introduction of these approved methods the laundry business has been elevated to a higher industrial plane than it had previously occupied. The improved equipment was not adopted because of its labour-saving characteristics, but because the quality of work is better. Many of the processes are carried through by electricity in a way which would be possible with no other form of motive power. In the face of the experience of this installation it is certain that the plants of the future will be electrical, if the designers are imbued with modern ideas.

Not later than July 1, this year, the New York Telephone Co. will put in effect a 5-cent pay station rate in Manhattan and Brooklyn, as against the present pay-station rate of 10 cents. The 5-cent rate will become operative in both boroughs at the same time, and the only reservation that will be made will be at hotels, where the hotel management itself holds to the present 10-cent rates for service from rooms and apartments.

An Up-to-Date Power House Fuel-Handling Equipment

By S. HOWARD-SMITH

THE general arrangement of machinery for handling coal and ashes in the power house at the wheel foundry of the Pennsylvania Railroad, at Altoona, Pa., is simple, and presents no novel feature. The mechanical equipment, however, is novel and interesting, both in type and in detail.

The pivoted-bucket carrier, through the various stages of its evolution, is a familiar machine to all interested in or concerned with power house equipments. In its original form it was composed of non-overlapping buckets placed as closely together as freedom of revolution about their pivots would permit. Leakage of fine coal and dust between the buckets, however, proved so objectionable as to condemn this form.

Overlapping lips were then added to one, and, subsequently, to both ends of the buckets. These lessened, but did not wholly prevent, the leakage, and made necessary special contrivances for causing the buckets to pass free of each other when, in the path of their travel, it became necessary to change their relative position.

Up to this point the evolution of the conveyor was guided by effort to lessen the results of an inherent defect, but suggestion of radical cure was not forthcoming. It remained for the inventor of the "Dodge" pivoted-bucket conveyor to recognize the fact that leakage between pivoted buckets could not be wholly prevented, and to present a machine which simply and effectively takes care of and conveys to its destina-

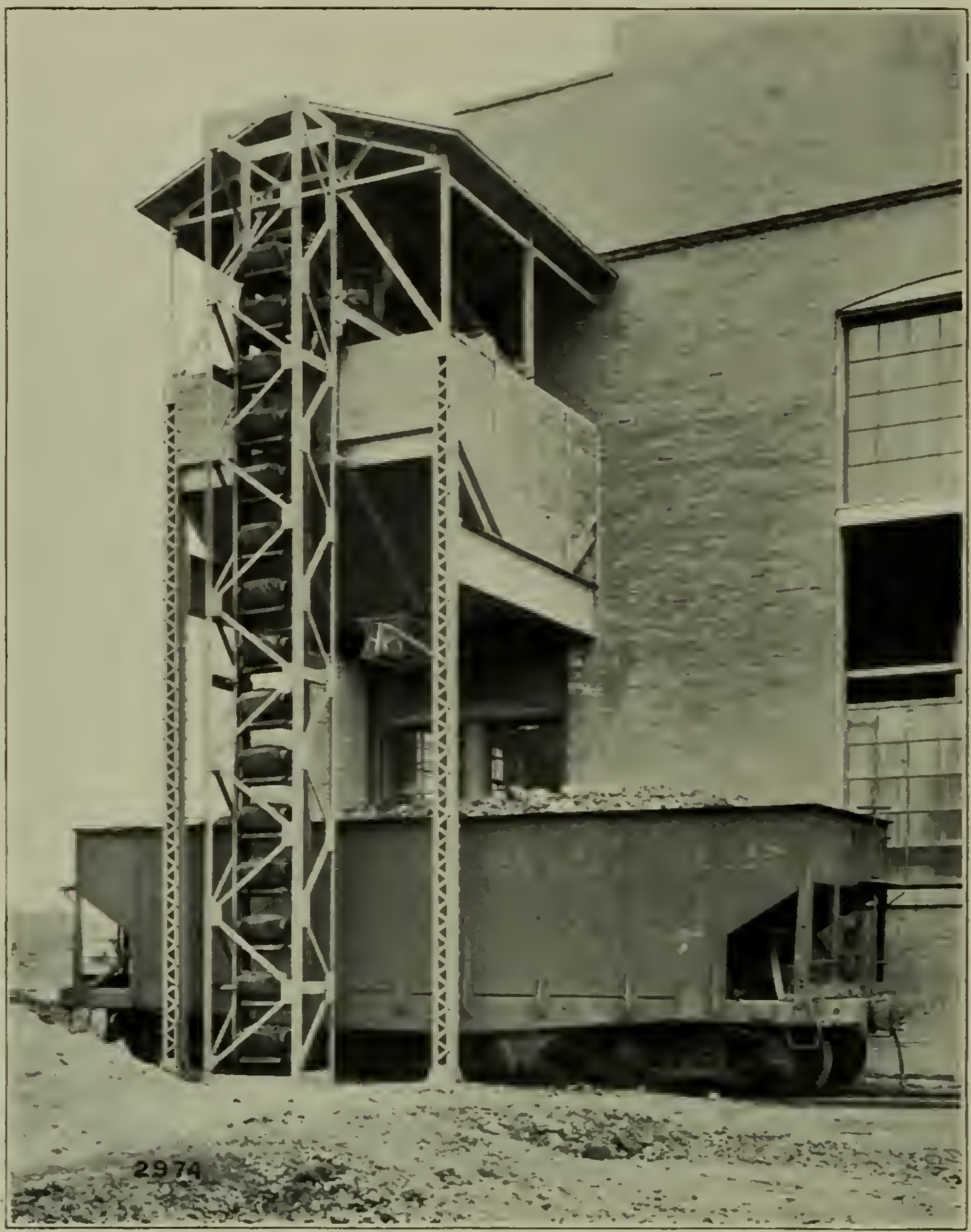


FIG. 1.—AT THE POWER HOUSE OF THE PENNSYLVANIA RAILROAD COMPANY'S WHEEL FOUNDRY AT ALTOONA, THE COAL FALLS FROM THE CAR INTO A HOPPER BENEATH THE TRACK, AND A RECIPROCATING FEEDER DELIVERS IT TO A CRUSHER. IT IS THEN CONVEYED UP TO THE STORAGE BIN ABOVE THE BOILERS

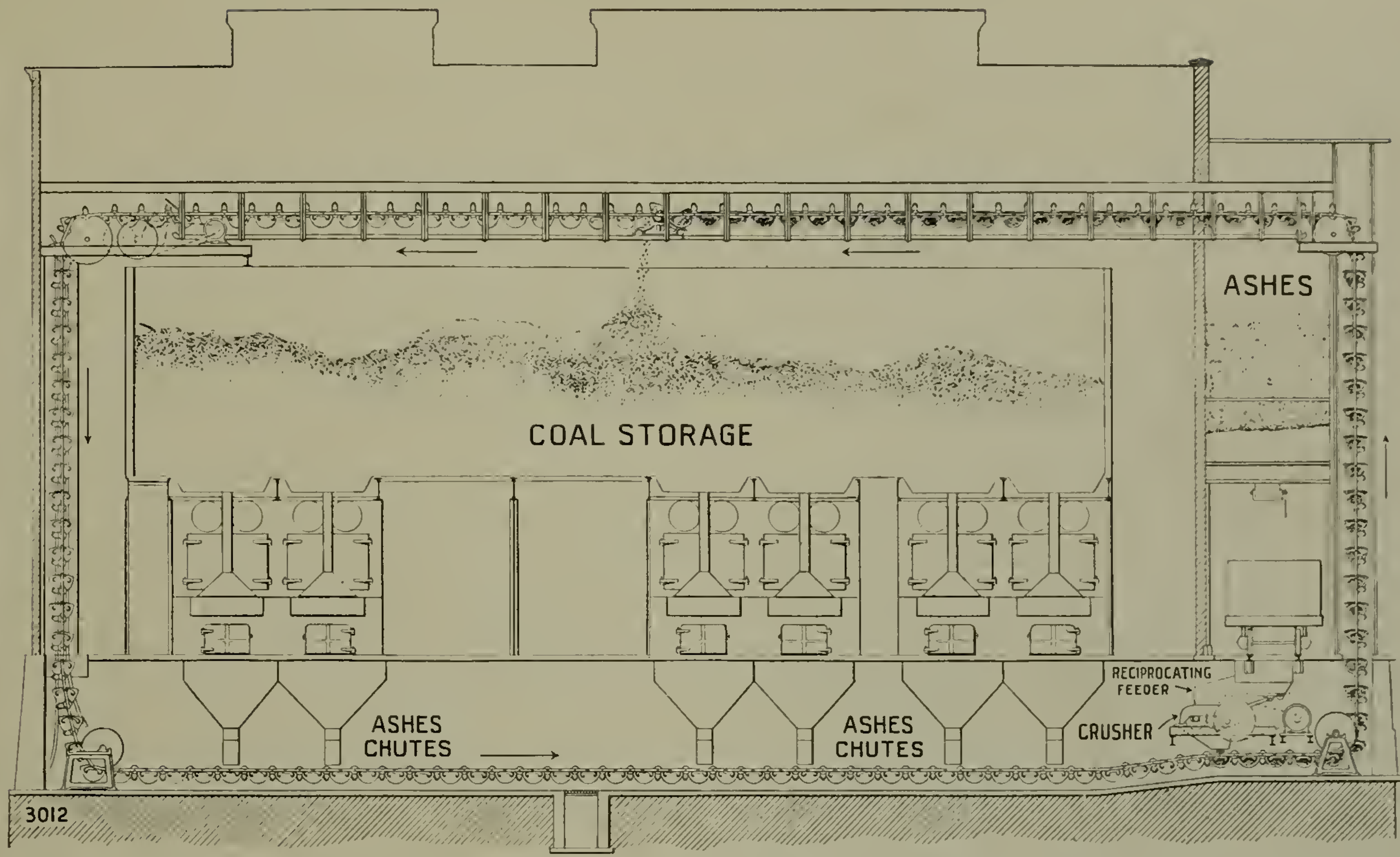


FIG. 2.—A SECTIONAL VIEW OF THE POWER HOUSE, SHOWING THE ARRANGEMENT FOR HANDLING COAL AND ASHES

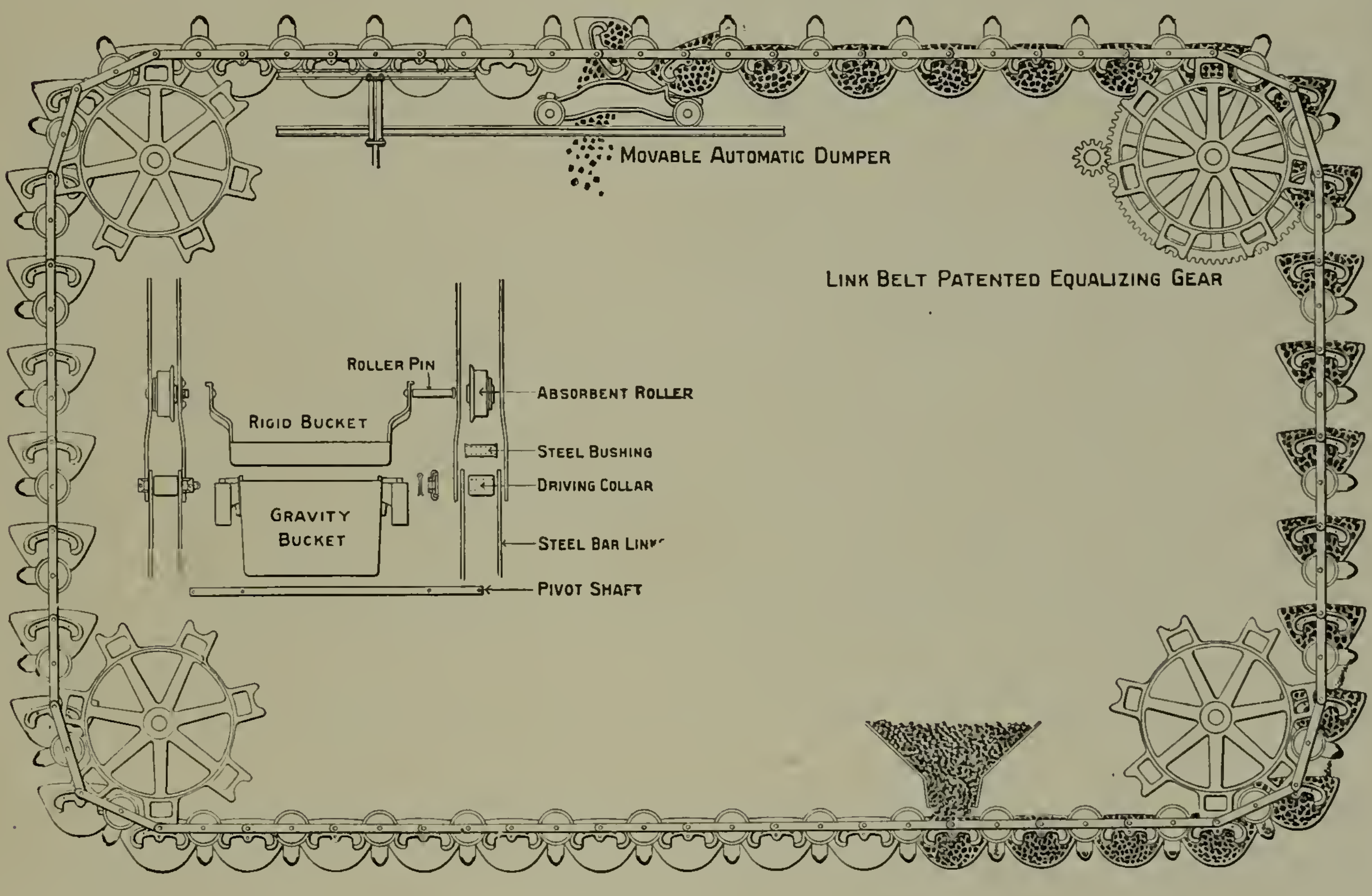


FIG. 3.—DIAGRAM SHOWING THE DETAILS OF THE CONVEYING SYSTEM. THE MOVABLE AUTOMATIC DUMPER IS CONTROLLED BY A WIRE ROPE WOUND ON A DRUM, THE LATTER BEING OPERATED BY A HAND CRANK

tion the material which leaks between the buckets, as well as that which is delivered to them.

As will be seen in Fig. 1, the coal is brought to the power house in standard cars on a track which is encircled by the conveyor. Falling from the car into a track hopper, the coal is delivered by a reciprocating feeder, insuring regularity of feed, to a crusher beneath, from which it is discharged through a chute into the pivoted buckets of the conveyor, and by it stored in the bin above and in front of the boilers. From this bin the coal is fed by chutes leading to automatic stokers.

Ashes, in turn, are delivered to the same conveyor through chutes, shown in Fig. 2, and discharged into the ash bin located outside of the building and above the track hopper previously mentioned.

The conveyor elevates about 39 feet and conveys horizontally 130 feet; its capacity is 40 tons per hour at a speed of 40 feet a minute. A 10-H. P. General Electric motor supplies the power to drive it, and a duplicate motor is employed to operate the crusher and reciprocating feeder.

In detail, the conveyor is composed of 18-inch x 24-inch, non-overlapping, malleable-iron buckets travelling between steel-bushed strap

chains and supported on rails by absorbent rollers, a smooth and uniform rate of travel being secured by the equalizing gear through which power is applied, as shown in Fig 3.

The particular feature of this conveyor, which differentiates it from all other gravity-bucket conveyors, links to which they are attached. The result of this will be obvious from the illustration. Whatever leak there may be at the feeding point is caught by the auxiliary buckets and carried in them till the conveyor makes its turn from horizontal to vertical, when the material which

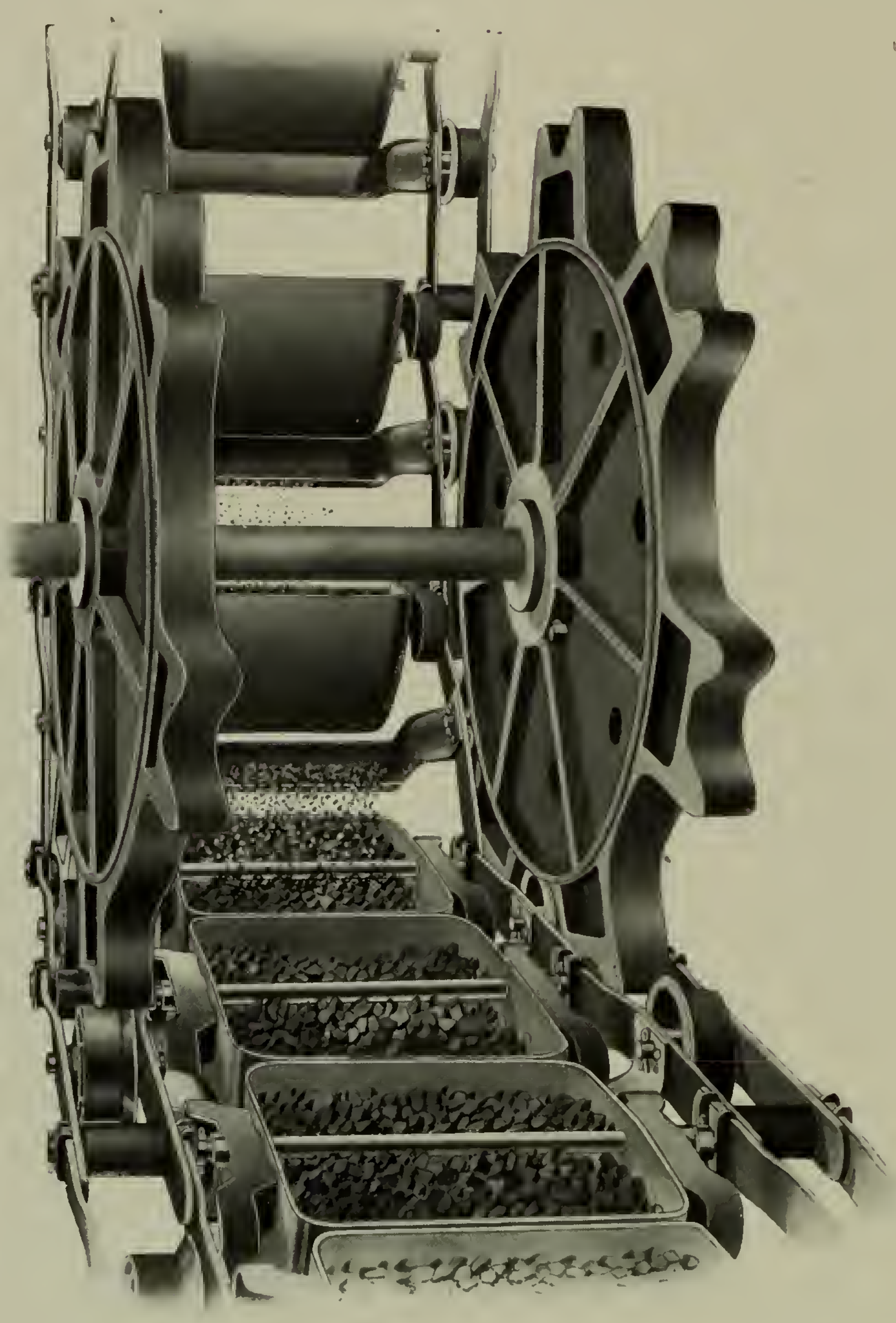


FIG. 4.—THE LEAK-BUCKET IS RIGIDLY SECURED TO THE SIDE BARS OF THE CHAINS, AND IS UNDER THE GAP BETWEEN CONSECUTIVE BUCKETS. IN TURNING FROM THE HORIZONTAL TO THE VERTICAL, THE COAL IN EACH LEAK-BUCKET IS DISCHARGED INTO THE CONVEYOR BUCKET FOLLOWING

is the auxiliary or leak bucket, which is rigidly secured to the side bars of the chains and so located as to be directly under the gap between consecutive buckets when the conveyor is in position to receive its load. The simplicity and adequacy of this arrangement will be seen in Fig. 4.

The buckets, being pivoted above their centre of gravity, maintain always the same horizontal position, while the auxiliary or leak buckets rigidly secured to the chains, remain always at right angles to the chain each bucket holds is discharged into the pivoted bucket following.

In practice, the results have been found most satisfactory. The conveyor illustrated was put in operation in February, 1905, and when inspected in June, the auxiliary buckets were found to be free from any accumulation and to always "spill clean." So trifling had been the escape of coal during four months of operation that it had not been found necessary to do any cleaning out of the tunnel through which the conveyor travels,—most gratifying results when it is considered that this conveyor is the first of its type to be installed for the handling of coal and ashes.

The discharge from the conveyor into the storage bin is governed by a movable tripper, shown in diagram in Fig. 3. This tripper is controlled by a wire rope wound upon a drum, the latter being operated by a hand crank.

Both coal and ash hoppers are of steel and concrete, and the entire installation suggests permanence in construction and sound engineering in arrangement and design. The contractors were the Link-Belt Engineering Company, of Philadelphia.

Preserving Telegraph and Telephone Poles

ACCORDING to "Forestry and Irrigation," seven electric companies in California have made arrangements with the United States Forest Service for a thorough co-operative study of seasoning and preserving telephone and telegraph poles. The work centers at Los Angeles, and an agent of the Forest Service will immediately take up the preliminaries there.

Oregon cedar is the tree chiefly used in this region for poles. The experiments will be devoted not only to the handling of this wood, but to a search for satisfactory substitutes among other species. Possible substitutes are Western yellow pine, incense cedar, redwood, and eucalyptus. The comparative value of these will be studied, and those which promise best will be subjected to such seasoning and preservative treatment as the Forest Service may recommend. In general, the wood will be handled in much the same manner as that which has proved successful in other work done by the service.

In Pocahontas County, West Virginia, also, the Postal Telegraph-Cable Company has established a camp for the cutting and treatment of chestnut telephone poles. The co-operation of the Forest Service was asked by the company to devise methods of seasoning and handling poles. The recommendations for seasoning, which have already been made, have been adopted by the company.

A number of poles will be soaked in water for about thirty days, to hasten seasoning. Other poles will be air-seasoned without soaking. The value of soaking will be demonstrated by a comparison of the results of these two methods.

Gas Power in the Operation of High-Speed Interurban Railways

The Warren & Jamestown Single-Phase System

THE CATENARY OVERHEAD CONSTRUCTION AT A TURN-OUT

THE degree of engineering initiative required for the successful execution of an undertaking such as the system recently placed in operation between Warren, Pa., and Jamestown, N. Y., lends special significance to the results already achieved. Operating as it does the entire railway system in the vicinity, both urban and interurban, and thus assuming a high degree of responsibility in public service, the Warren & Jamestown system deserves special notice, not only in the adoption of the high-voltage single-phase railway system, but also in the exclusive use of gas power. The combination of these two elements establishes a precedent in the history of transportation.

The successful application of the large gas engine to railway work has been awaited with much concern, and the operation of the Warren plant has already contributed much valuable and encouraging experience. To obtain a clear idea of the conditions surrounding this particular service the railway system may first be described.

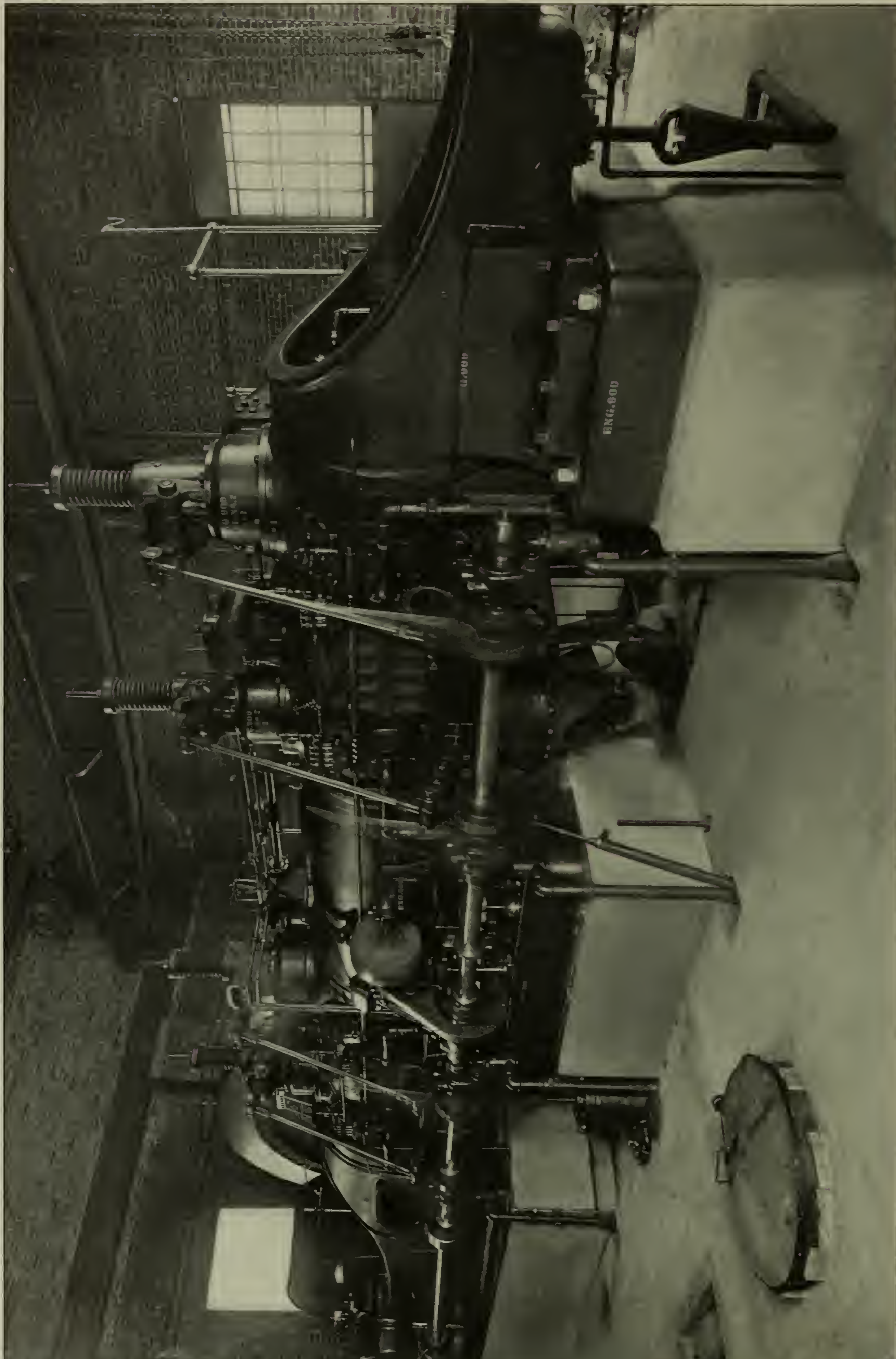
Operating between the two largest towns in the vicinity, it traverses a territory well populated, and exceptionally well situated to develop an extensive freight business. Warren, the southern terminal of the line, and the headquarters of the operating company, is located in the heart of the oil fields, and within the natural gas belt, which have contributed so largely to the material development of the western portion of the State.

It contains about 15,000 people, while its surrounding territory has a population of 10,000 more within easy access of the new road.

Jamestown, at the other end, is a prosperous manufacturing city of 29,000 inhabitants, and is connected by steam and electric roads with the attractive resorts of the Chatauqua region, the summer population of which is estimated at 50,000. The right of way, 22 miles in length between termini, passes through nine towns, totaling 50,000 population. Nine contiguous towns, with a population of 11,500, bring the total tributary population up to 61,500, exclusive of summer residents. Including these, the maximum tributary population is estimated close to 100,000 people. No direct competition exists, there being only a branch connection at Jamestown by trolley from the Dunkirk, Allegheny Valley & Pittsburg Railroad.

In general, the line is of good construction, a 70-pound rail, with gravel ballast being used, and is direct and fairly level, but abounds in curves with a few heavy grades, one in particular being of special difficulty, owing to its length of ¾ mile, a 7 per cent. maximum grade, and a necessary stop at the foot. These conditions unfortunately conspire to impose upon the power equipment a fluctuating load unusually severe at times.

The power house is located at Stoneham, 5 miles south of Warren, that site having been selected by reason of its proximity to the natural-gas pipe lines from which the fuel supply is obtained. The equipment includes two 260-KW., 380-volt, 25-cycle, alternating-current generators of the revolving-field type, direct-connected to horizontal gas engines operating at a speed of 150 revolutions per minute. The two units regularly operate together in electrical parallel with great ease and smoothness. The synchronizing adjustment is manual. The engines were constructed and erected by the Westinghouse Machine Co., and the



IN THE POWER HOUSE OF THE WARREN & JAMESTOWN RAILWAY, TWO HORIZONTAL DOUBLE-ACTING GAS ENGINES, BUILT BY THE WESTINGHOUSE MACHINE COMPANY, PITTSBURG, ARE DIRECT CONNECTED TO TWO 200-KW., ALTERNATING-CURRENT, REVOLVING-FIELD GENERATORS, BUILT BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG

electrical machinery was furnished and installed by the Westinghouse Electric & Manufacturing Co.

In the new type of horizontal, double-acting gas engine, the first of which is now operating at Warren, the resemblance to approved steam-engine practice is strong; in fact, the engine stands not as an example of radical change in structure, but as an adaptation to gas working of the ample steam experience of the builders in Corliss engines. Symmetrical design has been adopted wherever possible, notably in the cylinder casting with its symmetrical valve chambers, and in the pistons.

Anticipating an almost universal application to electrical working, a relay governing system has been devised which has proved entirely adequate in respect to both regulation and parallel working, and which places this type of gas engine upon the same plane with large Corliss practice. The absolute necessity of accessible parts has largely influenced the design of the engine and resulted in its elevation to such height that all parts are above the floor level. Inspection and cleaning, especially of cylinders, is possible without dismantling the engine.

Possibility of injury from neglect has been avoided by providing automatic auxiliaries, both oil and cooling water being delivered under gravity head, cylinder oil by positive pressure, and compressed air for starting from storage reservoirs. The starting arrangement has proved particularly efficient, and with only two operations, namely, opening up of gas valves and of air valves, the engine automatically starts and comes up to speed under its own ignition without further attention. On large engines considerably less than a minute is required to bring the engine up to speed, and, if desirable, a number of engines in a station may be simultaneously started from one point within this period of time.

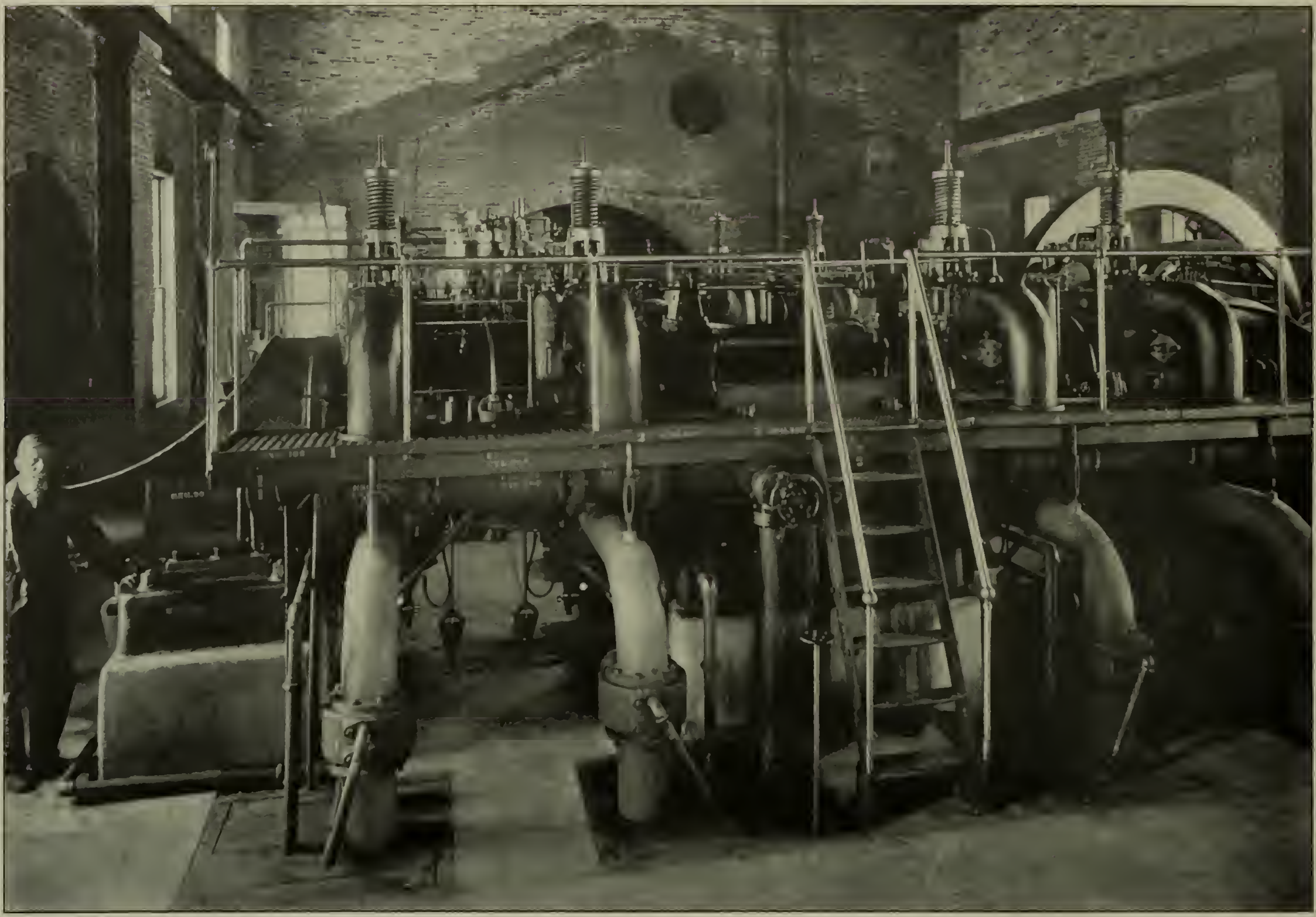
OVERHEAD CATENARY CONSTRUCTION ON STRAIGHT TRACK

To insure the greatest degree of reliability, a duplicate system of igniters is employed with four different combinations in each combustion chamber. Any igniters may be replaced while the engine is in service, and in case of necessity, any cylinder, or even the entire rear cylinder, may be isolated for repairs during operation.

There are two main generating units at present installed at Warren, with space for a third of equal size,—260-KW., 500 nominal H. P. Single-crank, tandem units were employed in place of twin tandem units in order to give greater flexibility of operation, the former representing the standard adopted by the builders. The units have solid couplings between engine and generator, and operate in parallel on the station load in precisely the same manner as an ordinary steam-driven unit. The familiar Boau de Rochas or four-stroke cycle is used, which, with the tandem arrangement, gives a power impulse with each successive stroke of the engine. Each cylinder is 21 inches in diameter, with a 30-inch stroke, the unit running at a nominal speed of 150 revolutions per minute. For this particular service the engine is rated at 470 B. H. P., with a maximum of 520 B. H. P., giving a 35-per cent. overload capacity on the generator.

Of the three housings which support the cylinders free from the foundations, only that in front is anchored, to allow the engine to adjust itself to temperature changes. From above and below, the interior of the cylinder is accessible through valve openings, so that it is not necessary to remove the heads. The jacket walls are cast separately.

For the crankshaft bearings, a segmental construction, with wedge adjustment and water-cooled shells, has been adopted. Both the pistons and the rod are water-cooled, and



THE GAS ENGINES ARE OF THE 4-CYCLE TYPE AND HAVE EACH TWO CYLINDERS IN TANDEM, THUS GIVING A POWER IMPULSE WITH EACH STROKE

the front piston is mounted permanently on the rod, while the other may be disconnected. To facilitate handling, the rod is made in two parts, the joint being at the middle crosshead.

At each cylinder end, an inlet valve, under direct control of the governor, combines the functions of mixing, governing, and admission of the charge. Both inlet and exhaust valves are of the poppet type, of steel, and are water-cooled.

Ignition is of the hammer-brake type, in duplicate, with two independent sources of current. The point of ignition is changeable, and the igniter plugs are removable while the engine is running. An automatic safety stop is interposed in the igniter circuits.

Separate water circuits are provided for each important part, with open funnel discharge. The pistons are maintained at even temperatures by a double-ended plunger pump attached to the middle crosshead. The water supply for the entire engine is by gravity, with an automatic motor-driven pump for maintaining constant head.

A gravity flush system for oiling is provided with a filter and a positive-driven return pump. For the cylinder oil is provided a positive-timed oil injection from sight-feed pumps driven by the engine.

From the generators the current passes through the switchboard apparatus and controlling devices to raising transformers of the oil-immersed, self-cooling type, which transform the potential from 380 to 22,000 volts. The two feeders which leave the station are adequately protected by circuit breakers of the fuse type, disconnecting switches, low-equivalent lightning arresters and choke coils.

No. 6 bare copper wire is used for the high-potential lines, and is carried on porcelain insulators supported on chestnut poles. Each feeder connects with a transforming station, one of which is located 1¼ miles from the Warren terminal, and the other 1½ miles from the end of the line in Jamestown.

The transformer stations are built of concrete blocks and are of suitable size to permit a rise arrangement of the apparatus. Each contains two 150-KW., 22,000-3300-volt lowering transformers of the oil-immersed, self-cooling type, which are controlled and protected by fuse-type circuit breakers, and disconnecting switches in the high-potential circuits and by oil switches and enclosed fuses in the secondary lines. One of the secondary lines taps the 3300-volt trolley section, while the other feeds the city section of the trolley line through auto-transformers which are placed along the track, and which reduce the potential from 3300 to 550 volts. Both high and low-potential feeder circuits are protected by choke coils and low-equivalent lightning arresters mounted in the transformer stations. With a symmetrical arrangement of apparatus, that mounted on one side of the station is exactly duplicated on the other. The two transformers are connected in parallel, each having sufficient capacity to carry the entire normal load. Either may be readily cut out of service.

Operated entirely without attendants, the transformer stations require only occasional inspection. The building is fireproof, it contains no moving machinery or apparatus, and has adequate automatic protection, so that there is no likelihood of

trouble other than the opening of a circuit breaker because of excessive load. Entrance of the high-potential feeders is made through protected openings under the roof. The high-voltage feeder leading to the Jamestown transformer station is carried upon the pole line which supports the overhead construction.

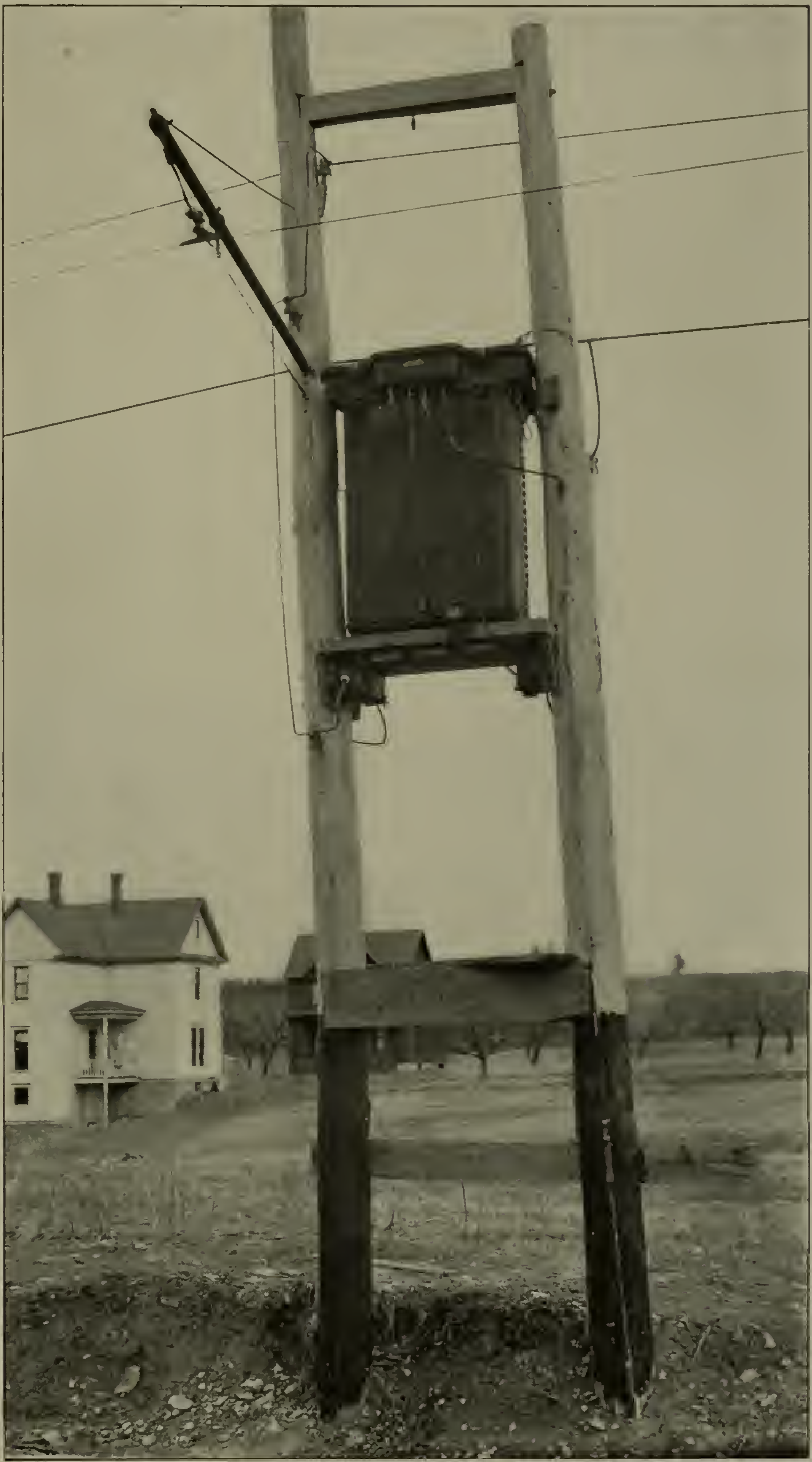
Of the central and two terminal sections, into which the trolley line is divided, the former is connected directly to the transformer stations receiving alternating current at 3300 volts. A No. 000 figure-8 trolley wire is swung by catenary suspension from a 7-16-inch messenger cable, which is carried on heavy porcelain insulators mounted on angle-iron brackets supported on the chestnut poles. The poles measure 7 inches at the top, and are 35 feet long. They are painted white and black and present a very attractive appearance, the white upper portions serving as useful guides to the line of track during the darkness of night. All poles will be numbered to facilitate the location of line faults and other troubles.

Much attention has been given to overhead construction, as may be seen by reference to the illustrations. A nice detail is the slight raising of one trolley wire at switch turn-outs, so that the bow trolley easily passes from one wire to the other without impairment of contact. At frequent intervals the messenger cable is anchored, and steady-strain brackets are used at curves and turn-outs. A few of the curves are constructed with pull-outs. The central high-voltage trolley line is separated from the terminal sections by section insulators.

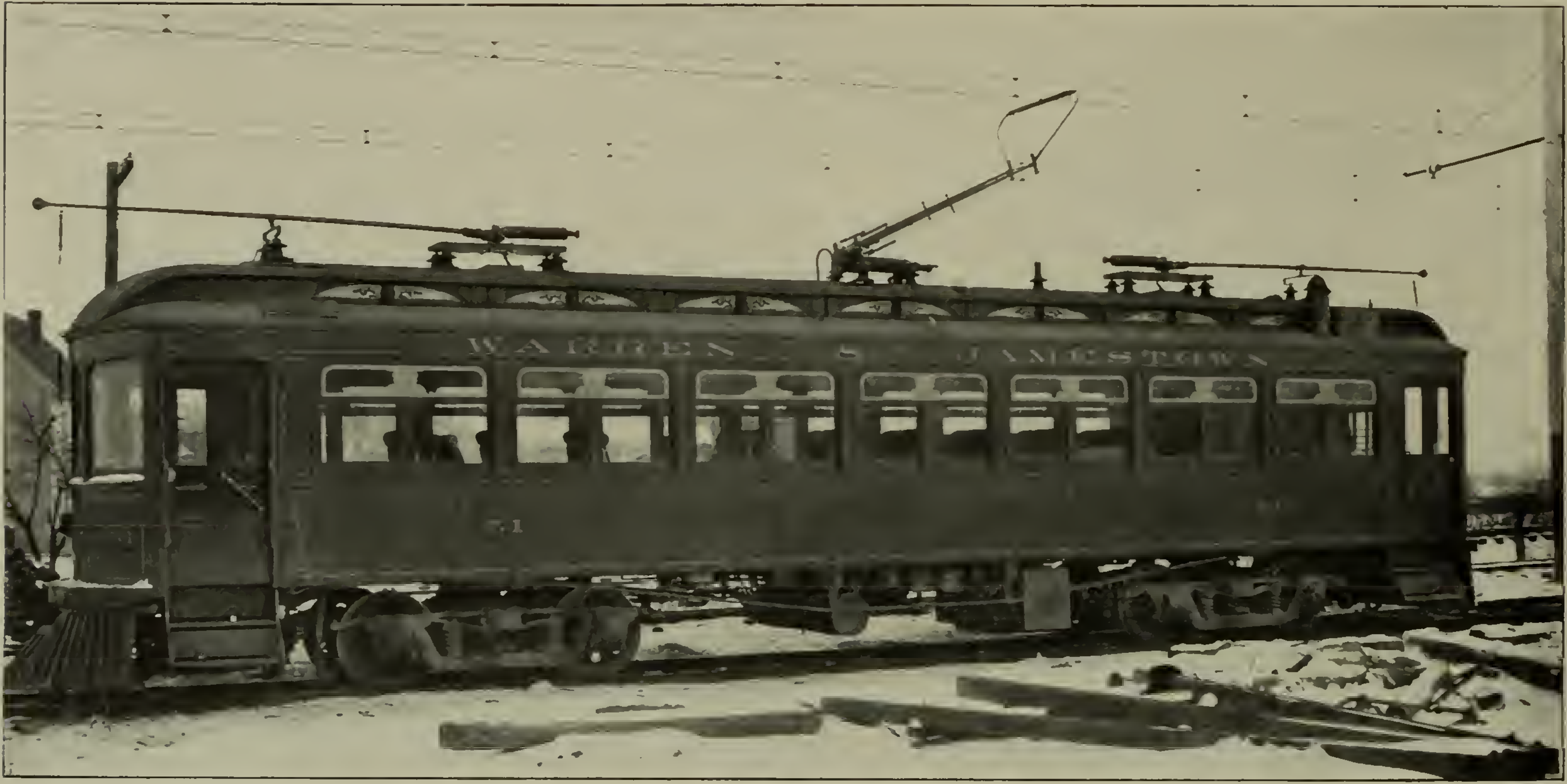
Within the limits of the terminal cities, the trolley lines are supplied with alternating current at the low potential of 550 volts. A feeder from each transformer station leads to three 75-KW. auto-transformers, which are located along the track and connected to a No. 0000 secondary feeder, which supplies the trolley. The auto-transformers, which are swung between pairs of poles, reduce the potential from 3300 to 500 volts.

The low-potential trolley line is supported from span wires by insulating hangers, in accordance with the practice standard for direct-current work. In Warren, the new cars run over the tracks of the Warren Street Railway Co., which is equipped with the direct-current system. The two trolley wires,—alternating current and direct current,—are suspended side by side from the same span without appreciably complicating the structure, or in any way impairing the service of either system.

Elegant in general appointments, the rolling stock presents one of the most interesting features of the road, particularly in the facility with which the cars are handled, and the easy and uniform acceleration obtainable. All controller points being running points, there is none of the disagreeable jerking in series and parallel running conditions often encountered



AN AUTO-TRANSFORMER FOR SUPPLYING THE LOW-POTENTIAL ALTERNATING-CURRENT TROLLEY IN JAMESTOWN



THE PASSENGER CARS, FOUR OF WHICH ARE IN USE, ARE WELL-FITTED UP AND ARE PROVIDED WITH SEATS FOR 59 PERSONS

in direct-current service. Five cars are at present in use, including a baggage or light freight car. Later, two more passenger coaches will be placed in service. The cars are 52 feet in length over all, having a seating capacity of 59 persons, and weigh about 35 tons total.

They are equipped with four 50-H. P. Westinghouse single-phase series motors connected in multiple with duplicate drum controllers. A multi-voltage transformer receives normal line pressure at 3300 volts, and delivers 550 volts to the motors, various lower voltages being used for different running speeds. These cars make a daily schedule speed of 19½ miles an hour, with stops averaging every 2½ miles. On through runs without stops, an average speed of 30 miles an hour has been maintained. Maximum speeds range as high as 50 miles an hour.

In addition to the foregoing interurban equipment, the company operates all the city lines in Warren, totaling 9 miles of single track, with seven cars in normal service. These are single-truck, two-motor equipments, of a total weight of about 10 tons. Formerly operated as a separate system, the Warren Street Railway now receives power from the main power house, operating in conjunction with the alternating-current equipment.

TRANSFORMER STATIONS ARE BUILT OF CONCRETE BLOCKS, AND CONTAIN TWO 150-KW., 22,000-3300-VOLT TRANSFORMERS, OF THE OIL-IMMERSED, SELF-COOLING TYPE

Current is collected on the 3300-volt section by bow trolleys held in contact position by compressed air. Within the city limits of Warren and Jamestown where this high voltage is not permissible, the current is collected by ordinary trolley wheels, which, however, are insulated for 3300 volts for use on the high-voltage trolley in case of accident to the bows.

Although greatly enlarged for the reception of the new machinery, the old power house site at Stoneham, a few miles south of Warren, is still used. Owing to the abundant supply of cheap fuel gas in the neighbourhood, the Warren company, at the time of its organization several years ago, decided to experiment with gas power for running their system. The results have been so much better than would be possible with gas-fired boilers and steam machinery as to practically dictate the selection of gas engines for this more recent and more important service.

Furthermore, the Warren & Jamestown Co. were not unmindful of the increased responsibility which would necessarily follow the establishment of an interurban system in the mat-

A BAGGAGE AND EXPRESS CAR. THIS, LIKE THE PASSENGER CARS, IS EQUIPPED WITH FOUR 50-HORSE-POWER, SINGE-PHASE SERIES MOTORS

ter of delay and inconvenience to passengers from interruptions to power supply, and it was apparent to them that the more reliable type of prime mover was an absolute necessity. To meet these conditions the Westinghouse Machine Co. was commissioned to provide the gas engine equipment of a type best known as the "heavy duty type," familiar to steam engine practice.

The new equipment is located in a rectangular brick structure directly adjoining the old gas-engine plant, which is still maintained as a reserve in the case of emergency. A few months prior to the opening of the interurban system, a 300-H. P. vertical type Westinghouse gas engine was installed to drive a converter, the machine first serving the direct-current city road, and later the alternating-current interurban road, until the main power units could be placed into service. This "rotary" is now employed to good advantage for supplying the city system from the main alternating-current plant, operating as a simple rotary. In case either side of the alternating current or direct-current plant requires assistance, this rotary will be belted to the reserve engine operating either as an alternating-current or direct-current generator. A 150-ampere (hour rating) storage battery assists in absorbing the fluctuations of the city load. It floats on the system without a booster, and was first installed for purposes of regulation to assist the old gas-engine plant.

A most noteworthy feature of the plant is its ability to cope with the violent fluctuations in load due to the demand for current on heavy grades, and simultaneous starting of cars. Owing to the small number of cars in service at any one time, the individual power demands are most keenly felt at the station, and rarely overlap in such a manner as to smooth out the station load curve. As a result, the load imposed upon the generator units is incessantly fluctuating frequently from zero to maximum, which would tend toward extreme difficulty in accomplishing good regulation, not only in potential, but particularly in speed. For the former a voltage regulator has proved of assistance; for the latter, the sensitive relay system of governing, before mentioned, holds the speed of the engine so close that variations can scarcely be detected by the ear, which, as is well known, is extremely sensitive in this regard.

In observing the operation of this system it is immediately apparent that the load conditions could not possibly be more unfavourable to the generating plant. This fact emphasizes the success which has already been obtained.

The Warren plant was started on October 19, 1905, and has since been in continuous service, averaging 17½ to 18 hours per day without developing the least troubles of a serious nature. The only prolonged shutdown was made after a two months' run for the purpose of examining the condition of the interior of the first unit started.

Daily observations of the gas consumption, given in the table herewith, show that during the month of December, 1905, the cost of gas consumed by the interurban system averaged less than 50 cents per hour, or about 16 cents per car-hour for 35-ton interurban single-phase cars. At present, the large gas engines operate both interurban and city systems, totaling ten cars. During the week ending January 12, the cost of gas averaged less than 75 cents per hour, or 7½ cents per car-hour for three interurban and seven city cars. With this combined operation there has been realized a saving of approximately 20 per cent. in cost of gas over the independent operation of the interurban and urban plants, the former by the new

COST OF OPERATION

1000-H. P. Gas Engine Plant, Warren & Jamestown Railway

December, 1905. Interurban System Only

Number of cars (35-ton)	3
Gas consumed, cubic feet	1,701,000
Gas per day averaged, cubic feet	54,900
Hours operated per day	17.5-18
Gas, per hour (operating), cubic feet	3,090
Cost of fuel per day	$8.24
Cost of fuel per hour run	.464
Cost of fuel per car-hour	.155

January 5-12, 1906. Interurban & City Systems

Number of cars—city (10-ton)	7
Number of cars—interurban (35-ton)	3
Gas consumed, cubic feet	625,000
Gas per day, cubic feet	89,285
Hours operated per day	18
Gas per hour (operating), cubic feet	4,960
Cost of fuel per day	$13.40
Cost per hour run	.744
Cost per car-hour	.0744

Month of January, 1906. Interurban & City Systems

Number of cars—city (10-ton)	7
Number of cars—interurban (35-ton),	3 to 4, average 3½
Gas consumption, cubic feet	2,745,000
Gas per day, cubic feet	88,550
Hours operated per day	18 +
Gas per hour (operating), cubic feet	4,900
Cost of fuel per day	$13.27
Cost per hour running	.735
Cost per car-hour	.07

horizontal, and the latter by vertical, type engines.

Fuel gas is available from several different points, and is clean and uniform in quality, averaging from 1000 to 1100 B. T. U. total per cubic feet. Gas is obtained at a straight rate of 15 cents per 1000 cubic feet, which places the cost of power so far below the usual figure that any other source of motive power is out of the question.

The credit for this combination of gas power with single-phase working lies with D. H. Siggins, president of the Warren & Jamestown Co. Ten years ago he entered the electric railway field under extreme opposition, with little capital and no previous experience. The courage which he then exhibited in fighting against heavy odds is shown again in the present instance.

The Westinghouse Electric & Manufacturing Co.'s Finances

STOCKHOLDERS of the Westinghouse Electric & Manufacturing Co. will meet at East Pittsburg, March 26, to vote on a proposed increase in the capital stock and an issue of convertible bonds. The company has determined upon an issue of $15,000,000 convertible sinking fund 5 per cent. bonds, due January 1, 1931, convertible into assenting stock of the company at 200 per cent. after January 1, 1910, and redeemable after January 1, 1912, at 105 per cent. and accrued interest, with an annual sinking fund of $500,000, beginning December 31, 1907. From the proceeds of the bonds the company will retire all of its outstanding commercial paper and will have left ample capital to provide for extensions and for its continually increasing business. The trust indenture under which the bonds are to be issued is to provide that the property of the company shall remain unmortgaged, and is also to contain stipulations as to special security for the bonds. The entire issue of $15,000,000 has been purchased by Kuhn, Loeb & Co., New York, subject to the right of stockholders to subscribe at 98 per cent. and accrued interest. The outstanding commercial paper totals approximately $8,600,000, of which $2,600,000 consists of debenture 5s, $4,000,000 5 per cent. notes, and $2,000,000 6 per cent. notes, so that the proposed new bonds mean an increased indebtedness of $6,900,000.

George Westinghouse, president of the company, has issued a circular from which the financial statement given herewith is taken.

The average annual net earnings of the company and its said subsidiary companies for the five years ended March 31, 1905, available for interest and dividends have been	$3,626,388
The earnings available for interest and dividends for the eight months ended November 30, 1905, were	2,488,641
The annual amount required to pay the interest upon the $15,000,000 of bonds and all other interest charges is	1,231,000

The following statement is based upon the balance sheet of November 30, 1905, and shows the financial position of the company after the application of the proceeds of the sale of the $15,000,000 of bonds and the payment therefrom of the company's commercial paper and other floating debts:

ASSETS

Plant, including real estate, factories, machinery, etc	$10,938,764
Quick assets, including cash ($4,644,162), accounts and bills receivable, materials, work in progress and manufactured products	22,336,213
Investments, including stocks and bonds of other companies	21,696,213
Other assets, including patents	6,951,029
Total	$61,922,220

LIABILITIES

Capital stocks outstanding	$24,998,700
Convertible sinking fund 5 per cent. gold bonds	15,000,000
Current accounts for purchases, etc	1,357,848
Debenture certificates	2,500,000
Collateral notes	6,000,000
Surplus	12,065,672
Total	$61,922,220

Interurban Electric Railway Developments in 1905

THE year 1905 has witnessed some notable improvements in the facilities of interurban lines, according to "The Interurban Railway Journal." The rapid growth of the system in the Central West has brought about new conditions of long-distance travel, interchangeable mileage, sleeping cars, dining-cars, and in the handling of local freight. Sleepers for interurbans are one of the latest innovations and are destined to become very popular in the future. In some cases where the run is not yet long enough to justify sleepers, parlour cars have been put on temporarily until long-distance connections can be made.

Another progressive step of the present year has been the formation of plans for through interurban traffic, not only by interchangeable mileage on interurbans, but also in co-operation with steam roads. Some interurban lines have made traffic arrangements with certain steam roads whereby tickets may be sold at stations on the interurban acceptable on steam lines to cities reached by the steam roads. This arrangement has worked satisfactorily to both parties and is likely to spread. It is one of the progressive steps of 1905. On the whole, the year has been one of great activity in electric interurban business, and the prospect is that 1906 will show still further development.

The new lines constructed and extensions made during 1905 make it possible to travel by trolley from Western New York and Pennsylvania to the Mississippi River and beyond, and the closing of a gap in Central New York will enable one to make a continuous trolley trip from Maine to Missouri. There are far-sighted electric railway men who believe the day is not distant when there will be continuous trolley connection between Portland, Me., and Portland, Ore., perhaps not by a direct route, but continuous.

There is a continuous trolley connection from Akron, Ohio, to Kalamazoo, Mich., 305 miles, and the connections are such that the distance can be covered by electric railway in less time than by steam, and at about one-third less cost. A trip from Indianapolis, Ind., to Zanesville, Ohio, 250 miles, can be made in one hour less time by electricity than by steam. All these long-line connections have been made during the past year.

In Great Britain, says the London "Engineer," the electric long-distance transmission problem has barely been touched outside Wales, much less dealt with in any conclusive fashion. It is, of course, true that we have current transmitted at 5000 to 10,000 volts—a thing done for many years from the Ferranti Deptford station. But the transmission has been, until quite recently, by insulated underground cable, a system incomplete with the supply of light and power in huge quantities from the colliery districts and the open country to places at a considerable distance. Popular prejudice has no doubt something to do with the matter, but no rational electrician, at all events, doubts the ultimate adoption in Great Britain of methods which have attained magnificent results elsewhere.

St. Petersburg is now the only European capital in which electricity has not replaced horses for street cars. However, the Russian Westinghouse Company has recently secured a contract for a municipal line to take the place of the horse car lines. Steam turbines,—the first in Russia,—will be installed in the power house.

Artificial Illumination—X

By DR. EDWIN JAMES HOUSTON

INTERIOR ILLUMINATION—Continued.

IN addition to the class of interior artificial illumination in use in department stores, and already described, there still remain the various other types referred to at the end of the preceding article. The special types of illumination included under these separate headings will necessarily vary with the particular kind of work to be accomplished. For the sake of convenience, all these remaining types can be arranged under the following four general heads:—

First Type.—That which requires a general steady, uniform light, of not too great intensity, throughout the entire space that is to be lighted, with such a limited or special illumination on the surface of the work as will insure the most distinct vision. Consequently, either too feeble, or too brilliant illumination is to be avoided. In some cases, true daylight colour values should be present in the light, while in other cases, the presence of such colours is a matter of comparatively little importance.

This type of illumination is necessary for the following special sub-types of lighting:—

(a) Office buildings.
(b) Banks, saving fund societies, brokers' offices, and the like.
(c) Libraries and reading rooms
(d) Counting rooms.
(e) Ticket offices.
(f) School rooms.

Second Type.—That which especially requires a steady light throughout the entire space that is to be illumined and a concentration of the light on particular surfaces, the concentration, however, being much less marked than in the first type. In some cases, however, in this type of interior illumination, a fairly strong light is required to be concentrated in certain portions of the building.

This type of interior illumination is necessary in the following special sub-types of lighting:—

(a) Churches.
(b) Lecture and concert halls.
(c) Ordinary dwelling houses.
(d) Sleeping rooms and hotels.

Third Type.—That which requires light of marked brilliancy and fairly marked uniformity throughout the entire space that is to be illumined, with a complete absence of shadows on the floor, walls and ceiling; in other words, an illumination in which all objects in the rooms are brilliantly illumined. In lighting of this character, the presence of daylight colour values is a matter of the greatest consequence.

This type of illumination is necessary in the case of the following special sub-types of lighting:—

(a) Ball rooms.
(b) Theatres.
(c) Lobbies, grand staircases and dining-rooms of large hotels.
(d) Bowling alleys and billiard rooms.
(e) Barber shops.

It may be mentioned in connection with the above, that the last two sub-types, i. e., billiard rooms and bowling alleys and barber shops, occupy in reality an intermediate space between this type and the first one.

Fourth Type.—That which, above all other things, requires such a lighting as will enable the workman to obtain the most distinct vision of his work. In these cases, the general illumination of the remainder of the room is, generally speaking, unimportant. It is, however, a matter of the greatest importance that the eyes of the workman should be protected against the entrance of direct light. According to the particular character of the work that is to be performed, the presence of daylight values is, in some cases, a matter of the greatest importance, while in others it is practically a matter of small consequence.

This type of illumination is necessary in the case of the following special sub-types of lighting:—

(a) Factories and mills.
(b) Workshops.
(c) Railroad stations.
(d) Train sheds.
(e) Subways and tunnels.

In addition to the above, there is a type of illumination, standing by itself, that can best be embraced under the heading of special illumination.

Before describing these different types of interior illumination, it should be borne in mind that it is frequently impossible, except in a general manner, to draw sharp lines of distinction between them. This arises mainly from the great variety of sub-types embraced in some of the general types, such, for example, as in factories, mills, and workshops, where the character of the work is often so varied as to cause the types to overlap. Generally speaking, however, the types named are sufficiently distinct to call for a specific illumination of the general characters referred to.

Let us take first the artificial lighting of large office buildings, such as the so-called sky-scrapers. While, generally speaking, such buildings are occupied during portions of the night, they are mainly occupied during the hours of daylight. Where the rooms are situated on the front, with proper exposure, the daylight illumination is sufficient, except, of course, during cloudy days or during the later hours of the day throughout the winter months. At such times, artificial lighting must be added to the daylight. In other suites of rooms, less favorably placed, however, artificial lighting is necessary throughout practically the entire day. At the same time, all the rooms in the building must be provided with a sufficient amount of illumination when they are used for night work.

Generally speaking, for illumination during the day, a sufficient quantity of direct sunlight or, preferably, diffused sunlight, enters the room to insure a uniform lighting throughout its entire space. The special work that requires additional illumination, in the greater number of cases, is the surface of a desk at which reading or writing is done. For such purposes, some suitable form of diffusing shade should be employed to throw the light downwards on the surface of the work.

Incandescent lamps are almost always employed for this, and since they are readily accessible and the character of the illumination is preferably that in which the light closely resembles ordinary sunlight in its daylight values, they should be of high efficiency. Generally speaking, the higher the efficiency,

the closer is the approximation of such light to daylight colour values. The small additional cost of the more frequent replacing of these lamps, arising from their decreased length of life, should not be permitted to stand in the way of the frequent

FIG. 1.—AN ADJUSTABLE PORTABLE LAMP HOLDER AND SHADE MANUFACTURED BY THE HENRY D'OLIER, JR., COMPANY, PHILADELPHIA

change from old to new lamps, which the use of the higher efficiency lamp necessitates.

Unfortunately, in the great majority of cases in office buildings, either by reason of the negligence of the engineer in charge, or through the unwise policy of the superintendent, lamps are permitted to remain not only under the shades employed for desk or table lighting, but throughout all parts of the building, long after they have reached their smash-

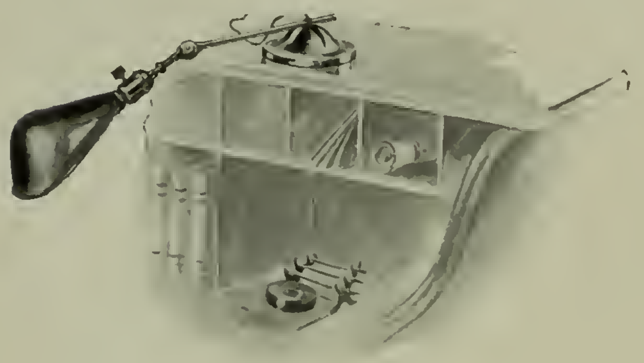


FIG. 2.—THE D'OLIER PORTABLE LAMP SHADE IN USE FOR DESK LIGHTING

ing point. This is the point in the life of the incandescent iamp at which it is not only better, but also much cheaper to throw the lamp away and replace it by a new lamp, even though it still continues to furnish a fairly good light.

There is no longer any reasonable room for doubt that, as a mere question of cost, it is cheaper to replace the lamp under such conditions than to permit it to continue to burn. This is due to the fact that the amount of electric current required to operate the lamp is far greater than that required to produce a greater amount of light with a new lamp. Hence, the cost of replacing the lamp is much less than the increased cost of coal required for the production of the electric current arising from the continued use of lamps that should long ago have been broken.

Since all office buildings must be provided with a sufficient quantity of light for night illumination, additional incandescent lamps, or other lamps, must be employed for the general illumination of the room. In most office buildings, these are placed on chandeliers or electroliers provided with separate lamps covered by opaque or semi-translucent globes. Two types of illumination are employed in such cases. In the older class of office buildings, where the lamps are hung on chandeliers, there are provided, in addition to the incandescent electric lamps, a certain number of gas lights in case the electric lights should go temporarily out of service.

Under the more efficient installation of electric lighting apparatus, particularly in buildings that take their current from lighting companies, as a rule incandescent electric lighting only is employed, the incandescent lamps being hung on electroliers. Where chandeliers are employed, it is customary to place the electric lamps below the gas lamps, since the electric lamps are almost the only source of light employed. In such cases, the gas lamps are placed above the electric lamps. Unless, however, considerable care is taken with such a disposition, a spotty or irregular illumination of the ceilings of the buildings results from the shadows cast by the globes that are immediately above the incandescent lamps. This difficulty could be avoided by placing a few incandescent lamps above the gas lamps.

As regards the character of the shades employed for office desk work, generally speaking, transparent globes and shades, or even shades with some translucent material, should be avoided. With these, that portion of the light which is permitted to directly enter the eye is not only lost to the worker, but necessarily results in preventing the distinct vision of writing or printed matter.

Fig. 1 represents a form of opaque shade of the Henry D'Olier, Jr., Company, of Philadelphia, with an adjustable portable holder, in which the lamp and shade are placed on the surface of the desk or table. This shade is of metal, the interior being covered with a thin coating of aluminium paint, that possesses the power of irregularly reflecting or diffusing the light. Since, in any shade of this general type, every point on the illumined surface throws light in practically all directions, a uniform illumination is insured on all the work, while, at the same time, the opaque material of the shade prevents the entrance of the direct light into the eyes of the worker. Fig. 2 shows the same device placed on top of the desk.

Wherever, as is sometimes the case, some special character of work is to be performed in any of the rooms of office buildings, the character of the illumination should be specially arranged so as to meet the particular requirements. It is too often the case that the same disposition of lights is made in every room. While no objection can be urged generally to such a plan, yet when, on the occupancy of a suite of rooms by a new tenant, the general distribution of the light is greatly altered by the erection of partitions of more or less opaque material, a corresponding change should be made in the character of its general lighting.

Bearing in mind the great amount of correspondence work that is necessary in most office buildings, some carefully arranged method of artificial illumination should be provided for the stenographer. In many office buildings, this generally hard-worked individual is placed, either in some obscure corner of the room, or in a portion of the room that has been partitioned off from the main room in such a manner as to require the use of artificial light during practically all hours of the day.

For work of this character, good illumination is necessary for the clear reading of stenographic notes, as well as, in most cases, for the purpose of obtaining distinct vision on the keys of the typewriting machine. Care should be taken to provide for this purpose illumination of the best character. As in the case of desk illumination, the use of transparent or translucent shades is much less satisfactory than the use of an opaque shade; for it is especially necessary in this kind of work to permit only the light which is irregularly diffused from the work to enter the eyes of the worker.

Since in perhaps the majority of rooms in office buildings, bookkeeping or accounting is carried on, especial care should be taken to insure the proper illumination of the

desk, stand or table at which this work is performed.

For the proper illumination of banks and saving fund societies, there should preferably be provided a general illumination over the entire space of the room, which may advantageously be of somewhat greater brilliancy than that necessary for office buildings. This necessity arises from the fact that all portions of such rooms should be sufficiently lighted to enable people to write checks, examine money, and the like, before going to the window of the receiving or the paying teller. Desks should be arranged for the convenience of the depositors, and provided with a good form of shaded incandescent lamp. While there is practically but little difference between the illumination required for banks and saving-fund societies, yet, since in the latter the bulk of the patrons are composed of people who are not accustomed to banking business, the number of such tables and the conveniences placed on them can advantageously be made greater than in the case of ordinary banks.

The illumination of bank buildings is generally obtained by means of clusters of lamps placed under some form of deflector or shade near the ceiling, as well as by lamps supported on brackets along the walls of the room, comparatively near the floor, but at such a height as not to directly enter the observer's eyes. Where columns or pillars are employed, as is generally the case, and the ceilings are unusually high, an efficient means for additional illumination is insured by placing rings or circles of incandescent lamps around the sides of columns at about the same height as the side lamps placed around the walls of the room. Fig. 3 shows a cluster of incandescent lamps employed in this manner. As will be seen, this method not only insures a good lighting, but also possesses a marked artistic appearance.

Besides the general illumination of bank buildings, there should be provided special illumination at the side desks with conveniences for writing and endorsing checks, counting money, and filling out blanks required for the receiving teller.

At the desk or counter of both the paying and the receiving tellers, however, too great care cannot be taken to provide the form of light that is best suited for insuring distinct vision. The light for this purpose should be sufficient in amount, as steady as possible, so as to aid the tellers in carefully examining the signatures on checks, and in scrutinizing the money received so as to detect the possible presence of a counterfeit. As a rule, for such cases, special lights, on both the outside and the inside of the window, should be provided with shades especially designed to throw the light on the counter. Where an outside light is not employed, a small proportion of the light should be permitted to fall on the face of the person outside the window to permit the teller to recognize him.

As regards the proper illumination of the safe deposit vaults, which are now a part of most banking institutions, suitable tables or desks should be provided with shaded lamps of the same general character as those employed in the main building.

The high efficiency and the excellent daylight colour value of the Nernst lamp renders it very suitable for this type of illumination. Fig. 5 illustrates the lighting of the Germania Savings Bank, in Pittsburg, by the Nernst lamp. Here, as will be seen, the lamps are placed near

FIG. 3.—CLUSTERS OF GENERAL ELECTRIC INCANDESCENT LAMPS ARRANGED AROUND THE SIDES OF A COLUMN

FIG. 4.—A BROKER'S OFFICE, IN THE FRICK BUILDING, PITTSBURG, LIGHTED BY NERNST LAMPS

the ceiling of the room and on the top of the partition employed for separating the paying teller, receiving teller, and others, from the general run of the bank. It is the latter row of lights that is intended to provide illumination for the counter in front of the paying tellers' and the receiving tellers' windows.

FIG. 5.—A PART OF THE GERMANIA SAVINGS BANK, PITTSBURG, LIGHTED BY NERNST LAMPS

FIG. 6.—NERNST LAMPS ARE ALSO USED IN THE UNION SAVINGS BANK, PITTSBURG

This method of illumination, however, is not so good as what would be obtained by the use of single lamps properly shielded placed both inside and outside the partition.

A uniform illumination is obtained by the disposition of the lights on the ceiling and the top of the partition, sufficient for the lighting of the entire interior space, without the production in it of marked shadows. During the bright hours of the day the lights on the partition are not lighted.

Fig. 6 illustrates the artificial illumination by the Nernst lamp of the Union Savings Bank, in Pittsburg, Pa. Here a similar method of illumination is employed, lamps being placed near the ceiling of the room and on the top of the partition separating the outside space from that occupied by the tellers, bookkeepers, and clerks. In this particular case, additional lights are placed on the side of the columns nearer the floor in the neighbourhood of two of the windows.

Fig. 7 shows the lighting of the banking departments of the Colonial Trust Company by means of Nernst lamps placed on the ceiling near the skylight, on the top of the partition, and on a line on both sides of a girder extending the length of the room. In this, as in all the preceding cases, it will be noticed that the illumination of the space is of such a character as to bring out in the most efficient manner the architectural design of the structure.

The illumination necessary for brokers' offices does not differ materially from that required for banks and savings fund societies. Besides the general lighting of the room, the light should be sufficient to properly illumine the blackboard on which the varying prices of stocks and securities are marked. The illumination of the stock ticker is also necessary, and the general illumination must be such as to permit of reading and writing in different parts of the room. Fig. 4 shows the lighting of a broker's office by Nernst lamps.

The illumination of libraries and reading rooms belongs especially to the class in which the light, besides extending throughout the entire space, should be especially concentrated on the book that is being read. Here the lighting should possess, in a marked degree, the characteristics of uniformity and steadiness. The daylight values are, generally speaking, of but little importance, except in cases where books of coloured prints are being read.

For the comfortable illumination of a reading room, the light should be especially free from excessive heat, and of such a character as not to contaminate the air by the gaseous products of combustion. The tables and desks provided for reading should be supplied with shades that diffuse the light and throw it uni-

formly over the surface of the desk or book, and, of course, prevent it from directly entering the eyes of the reader. Consequently, glass globes are objectionable, while the shades of glass that are whitened on the inside and green on the outside, and are so commonly employed by many banking buildings and other similar places, though much better than the ground-glass globes, possess the disadvantage of permitting the green light to directly enter the eyes of the writer or reader.

For libraries and reading rooms, incandescent electric lamps of high efficiency furnish, perhaps, the ideal illuminant. Gas lights and lamps are especially objectionable, owing to their high temperature and their tendency to vitiate the air of the room.

The most objectionable feature in the illumination of many libraries and reading rooms is to be found in the distance above the reading table that the lights are placed. If this height is sufficiently great to preclude the possibility of its entering the eyes of the reader directly, it is too high to give efficient illumination to the book, whereas, if placed nearer the table, it is apt to enter the eyes of the reader. For such purposes, opaque shades only should be employed, and should come sufficiently near the surface of the book to prevent the direct light from ever entering the eye of the reader. In addition to these lights, there should be insured a general illumination of the entire space by additional lamps properly placed.

The illumination of counting rooms does not present any marked differences from the illumination of libraries, reading desks, and the like. Owing to the fact that the accountants are generally required to continue their work throughout the greater part of a long day, the greatest care should be taken to insure a sufficient, steady, uniform light. While daylight values are not essential, yet a fair approach to them is not entirely devoid of advantages, owing to the fact that the eyes should not be obliged to work for extended periods of time under a light that differs much in its general characteristics from ordinary daylight.

While on this subject of the general character of the light best suited for the accountant's or bookkeeper's work, which is characterized by long-continued use of the eyes in writing, it may be well to refer to a fact too often lost sight of; this is, taking care to insure the proper position of the desk, table, or stand on which such work is done, as regards the direction in which the daylight or other light enters the worker's eyes. This should always be from the left-hand side of the worker, so as to prevent the formation on the paper of objectionable shadows cast by the hand, which always exist when the illumination is obtained from the right-hand side of the worker. Moreover, care should be taken not to place the table so that the worker directly faces a window, since, under such circumstances, a large quantity of light directly enters his eyes.

The illumination of ticket offices should be of such a character as not only to throw a uniform steady light on the case in which the tickets are kept, but also on the surface of the counter, or desk, at which the money is received and counted. This light should be the best that it is possible to obtain, since the ticket agent must constantly be on the lookout for counterfeit money. The general illumination of the room should be sufficient to so illumine the face of the purchaser of tickets as to enable the ticket agent to readily distinguish the features.

The necessity for furnishing the best light possible at a ticket office arises, however, ecpecially from the fact that constant reference is being made to the railroad time-tables. Since the type and printed matter of the general run of time-tables is often in unnecessarily fine print, on poor paper, and frequently done in an imperfect manner, as much assistance as possible should be rendered the agent in at least giving him the best illumination of the time-tables.

Lights for ticket offices should be provided with opaque shades, of the general type which throws the light on the desk and keeps it out of the eye of the reader, differing in no manner in this regard from the light required for clear reading or writing.

It is seldom necessary to employ artificial illumination in schools, except for those at night. Where this is necessary, incandescent lamps, provided with suitable shades, are preferable. As in all cases of lighting of this character, the lamps should be hung so as to prevent the light from directly entering the eyes of the students. Since school-rooms are generally of comparatively small dimensions, perhaps the best method of obtaining general lighting is by means of indirect diffusion from the walls and ceiling of the room. To this end, these portions of the room should be finished in a fairly rough whitened surface, capable of diffusing the light.

Smooth painted walls, especially those covered with enamelled paint, and possessing in a marked degree the power of regularly reflecting the light, should be avoided. In rooms where the greater proportion of the

FIG. 7.—ANOTHER EXAMPLE OF BANK ILLUMINATION BY NERNST LAMPS. THE COLONIAL TRUST COMPANY, PITTSBURG

FIG. 8.—NERNST LAMPS IN THE INTERIOR OF HOLY TRINITY CATHOLIC CHURCH, PITTSBURG

work consists in reading, especially where the text is different from that of the mother tongue of the student, some provision should be made for the better illumination of the books. The same is true in rooms where writing and drawing are mainly carried on.

In all cases where blackboards are employed in school-rooms, some provision should be made for throwing a uniform illumination on the board. It is essential, for the proper use of a blackboard, that its surface should be of such a character as will irregularly reflect or diffuse the light. Generally speaking, slate boards are highly objectionable, since they reflect the light so regularly as to prevent a clear view of any writing to students sitting in such portions of the room that they receive the greater amount of light by regular reflection. For this reason a blackboard covered with some preparation, such as mixtures of lampblack, turpentine, or other liquid that insures a rough diffusing surface, should be employed.

It is for a similar reason that the surface of maps or charts in school-rooms should never be covered with varnish. Maps so covered are rendered practically worthless for certain parts of the room, as one can readily prove by a simple trial. Better far to permit the surface of the map or chart to become dirty and to replace it by a new map, than to subject the eyes of the students to an injurious strain in their endeavour to decipher the details on the surface, despite the flood of regularly reflected light thrown into their eyes when in certain portions of the room.

The second type of interior illumination requires, like the preceding, a general illumination throughout the entire space that is to be lighted. This illumination, however, is of a much lower intensity, or is far more subdued, than the general illumination required for the preceding class. Like the preceding, it requires concentration on the general surfaces of the books held by the congregation in the main body of the building. These books, however, are generally printed in fairly large type.

In certain portions of the building, however, such as the reading desk, pulpit, choir, or organ stand in churches, the reading desks of lecture halls, the music stands of concert halls, or in the sitting rooms and libraries of dwelling houses, a greater amount of light must be concentrated on these particular parts, the requirements being of the same general character as those for writing desks.

The chief essential for the proper illumination of a church is a fairly moderate lighting of the entire space, with the exceptions above pointed out in the case of the choir, reading desk, pulpit, and the like. It is an especial requisite in lighting of this character that the stronger lights required should be so protected by shades as to prevent the light from directly entering the eyes of the congregation. The most effective type of church lighting is that in which all the lights are concealed behind cross timbers near the roof, back of projections in the arches of the building, or back of any suitable objects placed on the sides of the building. Especial care should be taken to prevent the light from the pulpit from falling directly on the congregation.

Another objectionable feature to be found in the illumination of churches consists in the placing of lights directly in the chancel of the church, or in the neighbourhood of the altar, to which the eyes of the congregation are necessarily directed during certain portions of the service. Generally speaking, it is possible to place all the lights required

FIG. 9.—ANOTHER EXAMPLE OF CHURCH LIGHTING BY NERNST LAMPS

for the thorough illumination of the chancel and altar back of some projecting portion of the arch, so as to be absolutely out of the view of the congregation.

The method, employed in many churches, of lighting by means of clusters of incandescent lamps or gas lights, placed near the roof under large reflectors, results in a fairly uniform illumination, provided the shades throw off their light by diffusion instead of by regular reflection. As a rule, however, the general character of the illumination so obtained is not of the subdued type that it should be.

Fig. 8 shows a church lighted by Nernst lamps. Here, as will be seen, the lamps are placed close to the ceiling of the auditorium, so as to be above the line of direct vision of the congregation. As may be observed, the lights are in the direct view of the congregation, a great improvement that has been effected by placing these back of some of the pillars without decreasing the general uniformity and efficiency of the illumination. An exceedingly objectionable feature is that lamps are placed near the dome of the chancel immediately above the altar, where they are directly in the line of vision of the congregation.

Fig. 9 shows another church lighted by Nernst lamps. Here the general character of the illumination possesses the same objectionable features as in the preceding case, the lamps being placed so as to be in the line of direct vision of the audience. In the very beautiful character of architecture exhibited in both of these churches, a marked improvement in the illumination could have been made by placing all the sources of light out of the direct line of vision.

The artificial illumination of the ordinary dwelling house, the amount of light required, as well as its general character and distribution, will necessarily vary with the different rooms. The dining-room and parlour should, generally speaking, be provided with a greater amount of light than is provided for the rest of the house. The library and sitting room should be provided with a light of the same general character as is employed in libraries and reading rooms generally. The work-room or sewing room should be provided with a burner to throw the light on the work, and the kitchen should be especially well lighted. The character of the illumination required for bedrooms will, of course, depend on whether or not it is desired to read before retiring.

3-5

Lead-Covered Wiring

THE advantages and disadvantages of lead-covered wiring are discussed by John D. Mackensie in "The Electrical Review," of London. He also shows there how some of the disadvantages may be minimized. The advantages are enumerated as follows:—

1. The wire comes to the contractor, already provided with its own continuous metallic sheathing, and generally requires no further protection.

2. The sheathing is water tight, the whole installation can quite readily be made so, too.

3. The great flexibility of the wire enables it to be installed with much less damage to buildings.

4. The small diameter of the wire enables it to be used in surface work, where any other system would be an eye-sore.

5. The difficulty of making joints practically compels the adoption of a loop-in system.

The disadvantages urged against the system are many and various, but fall under two great heads, viz:—

1. Risk of injury during erection.
2. Risk of injury after erection.

To that, some add the risk of injury during manufacture. This, however, with the exception of one point, is no greater in lead-covered than in the ordinary taped and braided wiring. The one point of difference is in the heating to which the wires are subjected during the process of sheathing. Considering, however, the rapidity with which the wires are run through the lead press, and the tests which are afterwards applied to these cables, and which they successfully stand, the risk of damage seems very slight.

Before dealing more fully with the disadvantages attendant to the use of lead-covered wires, it may be as well to point out that, personally, I have no love for twin wires, either round or flat, considering it inadvisable, to say the least, to run the chance of an internal short-circuit inside a soft metal sheathing. It is far preferable to use single lead-covered wires, with the lead sheathing properly bonded and earthed, because it then requires two "earths"—one on each wire—before a short-circuit occurs and on public supply systems an "earth" on the live wire means the blowing of a fuse. For these reasons I do not intend to deal here with twin wires.

The risks of injury during erection arise from (a) the carelessness of the wireman, and (b) from the carelessness of other workmen.

(a) The careless wireman cuts into the insulation when stripping off the lead sheathing; overheats and softens the insulation when sweating the sheathing into boxes for a water-tight system; overlooks the pin-holes caused by heated air bursting through the melted solder at such boxes; pulls the lead sheathing too hard, so making it brittle, and then it cracks when bent; hammers on his saddles too tight, and perhaps puts them on twisted, so cutting the lead by the edge of the saddle.

(b) The carelessness of other workmen is shown:—By the plasterer who cuts the lead with his trowel; the labourer who drops a shovel on it; the joiner who nails the flooring board to it; and by any man who walks with hob-nailed boots over the top of it.

The risks after erection are:—

(a) The lead gives very little mechanical protection, from nails, for example.

(b) It may be successfully attacked by rats and mice.

(c) If a failure of insulation takes place, a wire cannot readily be withdrawn and replaced.

(d) Lead expands with increase of temperature, and may not go back to its original length when cold, and hence it may come in contact with other metals, or may even get cracked and broken.

(e) The electrical resistance of lead being high, contact with other metals may form a better "earth" than the proper earth connection.

(f) When an "earth" comes on, the lead may fuse at the point of contact as quickly as the fuse wire does.

(g) Pure water in the presence of air, and water containing salts in solution, such as ammonia, have a solvent action on lead.

(h) Decaying animal or vegetable matter under floors, produce acetic acid, which, acting on the lead sheathing, has also a deleterious effect by forming "white lead."

(i) The presence of other metals, such as brass saddles in damp situations, causes electrolytic action.

(j) Where the lead sheathing is bared back to allow the wire to enter a switch or other fixture, there is a tendency for the current to creep on to the lead and escape at some other point, causing electrolytic corrosion.

The next point which arises is the question,—"Is it possible to overcome or minimize the risks?"

Taking (a), viz., the careless wireman, it is quite possible to get careful workmen who will do none of these things. A careless workman will cut into the insulation when re-

moving the braiding from ordinary wire, will twist and kink the wire when drawing it into a conduit, will leave ragged edges on his conduit so as to tear the insulation, will attempt to draw too many wires into a conduit, so straining the insulation and breaking the strands of wires. Therefore, get rid of him as quickly as you can.

(b) The risk of injury from other tradesmen is always present, and where lead-covered wiring has to be carried out while a building is in course of erection, special precautions must be taken to avoid injury, such as laying temporary boarding over the ruins of wires on the floors, lapping up with tape where coming out through plaster work, etc.

The faults after erection make the most formidable list, but it is quite possible to minimize these considerably.

(a) This point is made a good deal of by the opponents of lead-covered wiring, but seems to me to be grossly exaggerated. During the last seven years I have only had three instances in which lead wiring was damaged through nails or similar articles having been driven through the plaster work.

(b) This again is much exaggerated. Rats and mice have teeth which can easily work havoc on lead wire, but they seldom do so, and my own personal experience supplies no instance. These rodents will only attack lead wiring or lead water-pipes when in the direst straits for food or drink.

(c) This is the only point where conduit systems can show any real superiority over the lead-covered. The usual method of lead-covered wiring is to plaster it right in, and consequently it is impossible to withdraw it without damage to the plaster work. Several years ago the writer adopted the system of putting thin close-joint tubing in such walls as would be plastered up solid, dropping the lead-covered wires down this tube and drawing them taut, then placing an insulating bush top and bottom of tube, thus giving the advantage of a conduit system and also some more protection against an exploring nail.

(d) Here we have a fault not so much due to the lead-covered wire itself as to its indiscriminate use. Where wiring is to be subjected to very great variations in temperature, lead should not be used, but the writer has never found the ordinary temperature changes in house or shop to have any appreciable effect on the lead sheathing.

(e) In order to overcome this, all that is necessary is to bond all the lead wires together at frequent intervals, and so get the advantage of all the sheathing. For this purpose the writer uses a solder containing a large proportion of lead, and has found no trace of electrolytic action even in damp situations after years of use.

(f) The foregoing method of bonding the wires together tends to prevent the lead sheathing melting before the fuse does.

(g and h) The solvent effects of water with either air or salts in solution are certainly a possible disadvantage, but no more so than with thin enamelled conduits, which rust through in a very short time. Except under very exceptional circumstances, the amount of acetic acid which can be formed by decaying matter will not seriously harm the average lead-covered wire.

(i) Electrolytic action between brass saddles and the lead sheathing may quite easily be overcome by the use of lead saddles, which are quite as efficient.

(j) The current creeping along the insulation and on to the sheathing and causing electrolytic corrosion, is also easily overcome by dipping the ends of the wires up to the sheathing in melted joint-box compound. This also helps to increase the insulation resistance of the whole job.

The faults which so often occur on lead-covering wiring are all due to carelessness in the workmen, or because the conditions under which the wire is to work have not been properly appreciated. And the advantages to be obtained by the use of lead-covered wire make it easily worth the time spent in considering all the necessary circumstances. An example of what not to do is illustrated by a case where lead-covered wires have been drawn into iron gas pipes laid in the ground, with the inevitable result, viz., breakdown.

Here the lead covering was no doubt scratched, and perhaps cut while being drawn in, by the roughness inside the tube, and then it lay touching the iron and perhaps surrounded by moisture, either leaking in through pipe joints or due to condensation inside the tube, thus giving the very best chance for electrolytic action.

No one knowing the limitations of lead-covered wire would suggest or carry out such an arrangement, instead of which the wire ought to have been laid either in wood troughing and pitched in solid, or drawn into smooth earthenware or concrete conduits. It is the adoption of such obviously foolish arrangements as indicated which has given lead-covered wiring a name for unreliability, and I trust the foregoing remarks may indicate, in some small measure, how to overcome some of the difficulties.

A Third-Rail Snow Test

THE New York Central & Hudson River Railroad recently conducted a series of tests to determine the effect of snow on the third rail with reference to the operation of electric locomotives. The snowfall at the time was considerable, completely covering the top of the third rail to a depth in places of four to six inches. The track over which the runs extended was provided in different places with five different types of third-rail arrangement:—the ordinary unprotected rail; a rail protected at the top; a rail protected at top and side; and the New York Central under-running rail.

The locomotive was equipped with an ordinary form of snow plow affixed to the pilot, which in removing the snow, failed to throw it clear of the third rail. On this account it was considered that the over-running rails would have given better service if the plow had not been used. In the course of the runs it was developed that the unprotected over-running rail gave practically as good results as the protected rail; and in both cases the operation was unsatisfactory, as the accumulation of snow on the third rail was not removed by the passage of the shoe, but gave increasing trouble owing to its becoming more packed and icy as the shoes were forced through it. Conditions on the under-running rail are stated as decidedly better. The position of the rail tends to keep the under surface, where the contact takes place, comparatively free from snow, and the passage of the shoe causes an improvement of the contact with each successive trip.

The entire results were taken to show that the third rail, as adopted by the New York Central, is the most favourable type now at hand, and that the usual form of snow plow should receive some modification for operation on third-rail roads.

It is proposed to utilize the fall in the Stanislaus River, in Central California, for the generation of electricity. A flume and ditch system $15\frac{1}{2}$ miles long will give a head of 1500 feet. The capacity of the plant will be 20,000 KW.

A Low-Resistance Thermo-Electric Pyrometer and Compensator

By WILLIAM H. BRISTOL

A Paper Recently Read Before the American Society of Mechanical Engineers, New York

FOR a great variety of industrial processes and also in scientific research, the ranges of temperature required do not exceed 2000 degrees F.

The low-resistance pyrometer described in this paper has been developed to meet the existing demand for an instrument to fully cover this range of temperature, one which would be accurate, reliable and comparatively inexpensive, taking into consideration both the initial cost and the cost of maintenance, and which might be readily adapted to varying conditions for industrial operations and be successfully operated by an ordinary workman.

As the title implies, this pyrometer depends primarily upon the well-known thermo-electric couple consisting of two dissimilar metals or alloys joined at one end. When the junction of such a couple is located at a point where the temperature is to be measured, an electromotive force is developed which is a function of, and depends for its value upon, the difference of temperature between the junction and the opposite or so-called cold ends of the two elements forming the couple.

The phenomenon of producing an electric current when the opposite junctions of two dissimilar metals or alloys are of different temperatures, was discovered by Seebeck in 1820. Le Chatelier, in his recent book on "High Temperature Measurements," states that in the year 1830, Becquerel had the first idea to profit by the Seeback discovery for temperature measurements.

During the seventy-five years since that date, many scientists have systematically studied and carried out investigations with thermo-electric couples, using a great variety of metals and alloys, with a view to discover a couple that would resist high temperatures and could be depended upon for constancy when used for their measurement. Le Chatelier, who has made extensive researches to determine the most desirable metals for this purpose, finally adopted a couple, one element of which consisted of pure platinum, and the other of an alloy of platinum and 10 per cent. rhodium. From this couple an almost uniformly increasing electromotive force is developed, corresponding with increasing differences of temperature between its opposite ends.

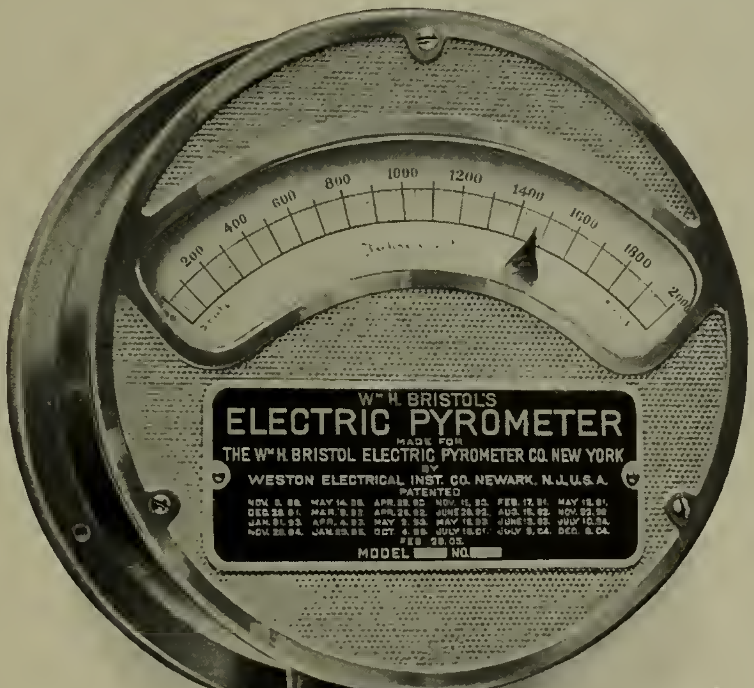


FIG. 1.—A LOW-RESISTANCE, THERMO-ELECTRIC PYROMETER, DESIGNED BY WILLIAM H. BRISTOL, NEW YORK

At the present time, many of these couples are successfully employed for the determination of high temperatures. They are almost invariably used in conjunction with an extremely delicate, high-resistance galvanometer, which according to Le Chatelier is indispensable, 200 ohms being mentioned as a minimum resistance allowable in the indicating instrument. This amount of resistance is necessary to practically eliminate the atmospheric temperature influence upon the resistance of the elements forming the couple, the leads, and the coils of the galvanometer itself.

If the galvanometer be of a high-resistance type, it is evident that if sensitive to the minute current of electricity corresponding to the very low electromotive force produced by the couple, it must be delicately constructed, and consequently requires great skill and care in its handling and operation. The sensitive coil of the instrument is usually suspended by an extremely fine wire, and the instrument must always be leveled and located upon a solid foundation before observations can be made.

The instrument with the platinum-rhodium couple, just described, may be classed as a high-resistance pyrometer when compared with the low-resistance pyrometer. The latter consists of three parts, namely, couple, indicator, and leads to connect them. The leads between the couple and the indicator may be of almost any desired length to meet the special requirements; the combined resistance of the leads, couple, and indicator is fixed to suit the total range of the instrument and varies from three ohms as a minimum to ten as a maximum. The indicator is a low-resistance instrument of special design and is made especially for the writer by the Weston Electrical Instrument Co., of Newark, N. J. The

accuracy, permanency, and portability of these instruments are well known.

Fig. 1 shows a wall or switchboard form of the indicator. Fig. 2 shows a portable form. These indicators are made with pivots in jewelled bearings in place of the delicate suspension by fine wires generally considered necessary in the high-resistance type of indicator or galvanometer for this work.

FIG. 2.—A PORTABLE TYPE OF THE BRISTOL PYROMETER

The elements used in the low-resistance system give a much greater electromotive force than the platinum-rhodium couple,—a great advantage in gain of motive power for the operation of the indicating instrument. The particular metals or alloys applicable to a pyrometer of this type should have a fusing point higher than the maximum temperature to be measured, and when formed into a couple should produce a high electromotive force with a practically uniform increase proportional to the increase of difference of temperature.

As the result of many experiments with different metals and alloys to determine suitable materials to meet these requirements, couples have been finally adopted consisting of alloys of tungsten, steel, nickel, iron, and copper, different alloys being employed to suit the total ranges of temperature which it is desired to have the scale cover. Since no rare metals are used for these couples, this part of the pyrometer is inexpensive and it is possible to employ elements of large cross-section. Hence, they will not be affected in their resistance any appreciable amount by the variation of temperature along their length.

The leads to the indicator are made of flexible insulated copper duplex cable, of ample cross-section to practically eliminate the influence of variations of atmospheric temperature. The cross-section of the elements of the couple is reduced at their junction, thus rendering the couple sensitive to sudden changes of the temperature to be measured.

A novel feature of the couple is that it is made separable at the point where it passes through the wall of the space within which the temperature is to be measured. The object of the joint is two-fold:—First, to make it possible to renew the "fire-end" whenever it may be necessary; second, to permit carrying the cold ends of the elements to a point toward the floor where the atmospheric temperature will be constant and not influenced by the temperature that is being measured. Fig. 3 shows a complete element with separable joint, coiled leads, and lamp plug on the end of the cable forming the leads, for convenient connection to the indicating instrument shown in Fig. 1.

FIG. 3.—A COMPLETE ELEMENT WITH SEPARABLE JOINT, COILED LEADS AND LAMP PLUG FOR CONNECTION TO THE INSTRUMENT SHOWN IN FIG. 1.

A special feature of the joint is that it is provided with large bearing surfaces to prevent possibilities of variations of resistance at the connection and is constructed to allow for easily breaking and making the connection. The details of the joint are shown clearly in Fig. 4, and from this it will be seen that it is impossible to make connection incorrectly, as is usually done when there is nothing to guard against it.

The low cost of the couples makes it practicable in the use of the instrument to keep an extra fire end in reserve. This may at any time be quickly substituted for the one that has been in continual service, thus affording an economical and positive check upon the accuracy of the instrument. The elements of the couple are independently insulated in a novel and effective manner by winding each with asbestos cord and then coating the surface with carborundum paint, a solution of silicate of soda being used as a binder. This makes a clean, compact and smooth insulation.

Couples thus insulated are flexible and can either be applied to the heated space directly or they may be insulated in a piece of ordinary pipe. This protection has proved to be effective and economical. For continuous applications of the couples to temperatures in the neighbourhood of 2000 degrees F. or over, special protecting tubes of nickel, plumbago or porcelain are employed.

These pyrometers are furnished with scales for total ranges of 600, 1200, and 2000 degrees F., shown in Figs. 5, 6 and 7, respectively. The graduations of these scales are determined by the fusing temperature of lead, zinc, aluminium and copper, these giving sufficient points on the curves for use in making a complete graduation of the scales.

The divisions are also further checked by the use of a standardized Le Chatelier platinum-rhodium couple, and a Siemens-Halske suspension galvanometer. For very open scales over shorter ranges, several couples may be placed in series, thus making it possible to read to small fractions of a degree.

A novel application of the thermo-electric couple is that of determining the temperature of molten metals, as cast iron, copper, brass, and bronze. It consists in leaving the ends of the elements disconnected and without insulation. When these ends are slightly immersed in the molten metal, a junction is made between the elements and the reading will be the same as if the elements of the couple had been originally joined. The ad-

vantage of this plan is that the reduced cross-section at the ends of the couple allows it to almost instantaneously attain the temperature of the molten metal and consequently there is no lag error—a most important advantage.

As the couple is used over and over again, the ends become worn away, but the couple is nevertheless always ready for use by immersion of a fresh portion, which will not be changed in any way by continued use and will give the same reading for a given temperature as if the couple had not been worn away. A joint is provided near the end that is immersed so that a fresh tip can be applied to the couple before enough of the end has worn away to appreciably affect the resistance of the complete system.

COMPENSATORS

As already mentioned, it is well known that the electromotive force generated by a thermo-electric couple is a function of the temperatures at the hot and the cold ends. For refined measurements, it is therefore necessary to make allowance for changes of temperature at the cold ends of the couple when readings are taken, unless some means is provided to maintain them at a constant temperature. This is sometimes done by immersing the cold ends in ice water or by having the ends surrounded by a water jacket through which there is a flow of water at some known temperature.

In the low-resistance, thermo-electric pyrometer system, comparatively small changes in the actual resistance of the circuit, including couple, leads, and instrument, will produce sufficient effect to correct for atmospheric changes at their cold ends. A compensating device to automatically correct for changes of atmospheric temperature at the cold ends has been devised, making it possible to dispense with the cumbersome means for maintaining the cold ends at constant temperature or the necessity of taking readings of temperatures at the cold ends.

Fig. 8 shows this compensating device. It consists of a glass bulb with a short stem, similar to an ordinary mercurial thermometer. Two platinum terminal wires are fused into the stem near its top and are connected within the bore of the stem by a loop of fine platinum wire, thus completing the circuit, as indicated in the diagram. The size of the bulb, the cross-section of the bore of the stem, and the cross-section of the platinum wire loop are proportioned to suit the case in hand.

The compensator will perfectly compensate for any particular point on the scale, as, for instance, the working point where it may be desired that the reading shall be absolutely independent of changes of temperature at the cold ends. It will readily be seen that if the temperature rises at the cold ends, the mercury rising in the stem will short circuit a certain portion of the platinum loop, thus reducing the resistance of the entire circuit by exactly the necessary amount. Hence, the diminished electromotive force of the couple due to the rise of temperature of the cold end will send the same amount of current through the circuit and instrument, and consequently give the same reading as if there had been no change of temperature at the cold ends.

Fig. 9 is a diagrammatic sketch showing the compensator connected in circuit. The compensator acts on precisely the same principle, but in a reverse manner, when the temperature falls at the cold ends, the resistance of the circuit being increased as the column of mercury lowers in the stem. The increase produced in the resistance of the circuit prevents the increased electromotive force of the couple, due to the fall of the temperature at the cold ends, from sending an increased current through the instrument; therefore the reading remains unchanged. The compensator may also be employed within the indicating instrument to correct for atmospheric changes of temperature upon the instrument itself where extremely accurate results are required.

GENERAL ADVANTAGES OF THERMO-ELECTRIC PYROMETERS

As compared with other forms of apparatus for measurements of high temperatures, the thermo-electric pyrometer has many advantages, of which the following are the most important:—

They may be employed where the space is extremely small and inaccessible.

They respond promptly to changes of temperature.

They are practically independent of temperature variations intermediate between those of their hot and cold ends.

They are independent of pressure and rough usage at the point where the temperature is to be measured.

The indicating instrument can be located at the most convenient point, practically at almost any distance from the couple.

They are extremely sensitive to changes of temperature and respond instantaneously, that is, there is no lag error.

They are constant in their indications when the couples are properly protected.

They permit the determination of the temperature at many different

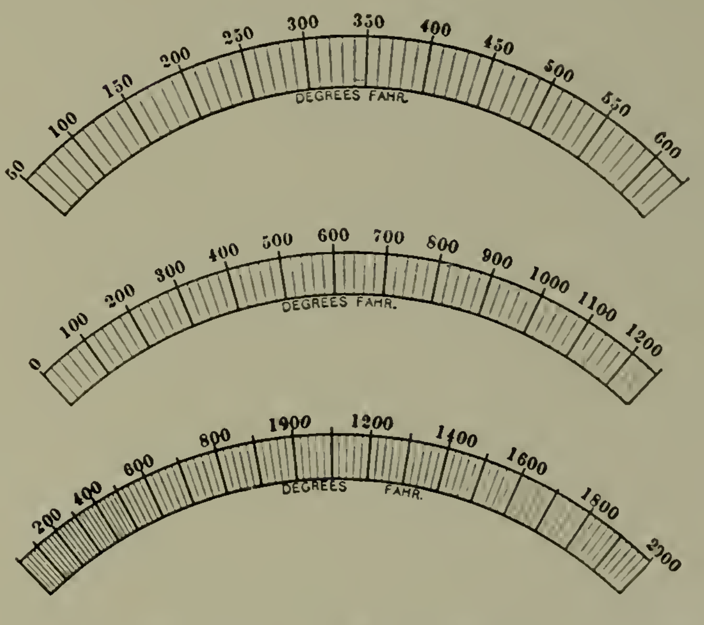
FIG. 4.—A LARGER VIEW OF THE JOINT BETWEEN THE FIRE-END AND THE PERMANENT PART OF THE THERMO-COUPLE

points by means of several couples and leads connected to one instrument, provided with a suitable switching device.

SPECIAL ADVANTAGES OF THE LOW-RESISTANCE SYSTEM

The important advantages of the low-resistance thermo-electric pyrometer system may be summarized as follows:—

1. A commercial switchboard type of portable dead-beat indicating instrument may be employed instead of the extremely delicate suspension



FIGS. 5, 6 AND 7.—THE PYROMETERS ARE PROVIDED WITH SCALES OF THE RANGES SHOWN

galvanometer required for use with a single platinum-rhodium couple. This advantage is gained by the fact, already stated, that the thermo-electric couples employed give several times as much electromotive force as the platinum-rhodium couples, this electromotive force being ample to successfully operate a pivot instru-

ment if the latter is of sufficiently low resistance.

2. It affords a practical method for automatically compensating for the changes of temperature at the cold ends of the couple, as already described.

3. It makes it practicable to use

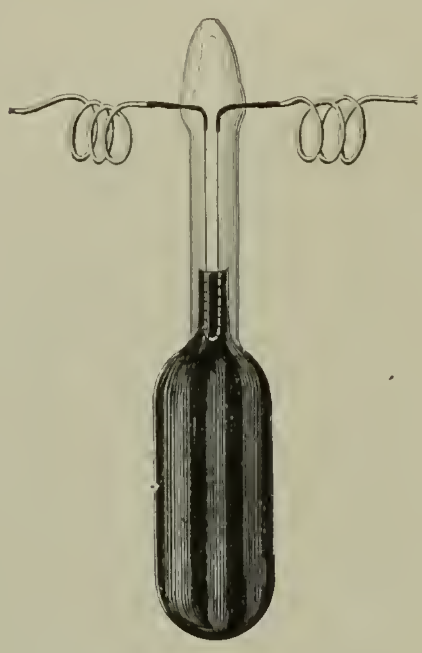


FIG. 8.—COMPENSATING DEVICE TO AUTOMATICALLY COMPENSATE FOR CHANGES OF ATMOSPHERIC TEMPERATURE AT THE COLD ENDS OF THE COUPLE

the same indicating instrument and the same couple for different total ranges of temperature by using different binding posts and having several scales drawn, the proper resistances being inserted for each individual total scale.

4. The application of low-priced metals and alloys as a substitute for platinum and rhodium makes it possible to install a number of couples, and by means of proper switching devices to use one instrument for quickly determining the temperatures at the locations of the different couples. In many instances the first cost of the expensive platinum elements prohibit their use in this way.

APPLICATIONS

Many applications of this instrument will suggest themselves. A few of the important ones will be mentioned:—In a boiler test nineteen couples were simultaneously applied at different points between the furnace and the flue. From the data obtained, a curve was drawn showing the temperatures at all points along the path of the products of combustion from the furnace to the flue, the abscissas corresponding to the square feet of heating surface and the ordinates to degrees Fahrenheit.

The value of such data for investigating and studying the economical working of steam power plants will be appreciated. The couple can readily be applied to the steam space of a boiler and can be used to show the degree of superheating.

These instruments have been also adapted to, and are especially valuable in, maintaining the desired temperatures for annealing, hardening, tempering, and blueing of steel.

When many small parts are handled, as in the manufacture of watches, a practical method of using the pyrometer is to adapt the pot containing the articles to the end of the couple and use the latter as handle for inserting the pot into the furnace or into an ordinary forge fire. By revolving the pot it is heated perfectly uniformly, and as soon as the proper temperature is reached it is known on the indicator and all guess work is eliminated.

They have been most successfully employed in lead-hardening baths.

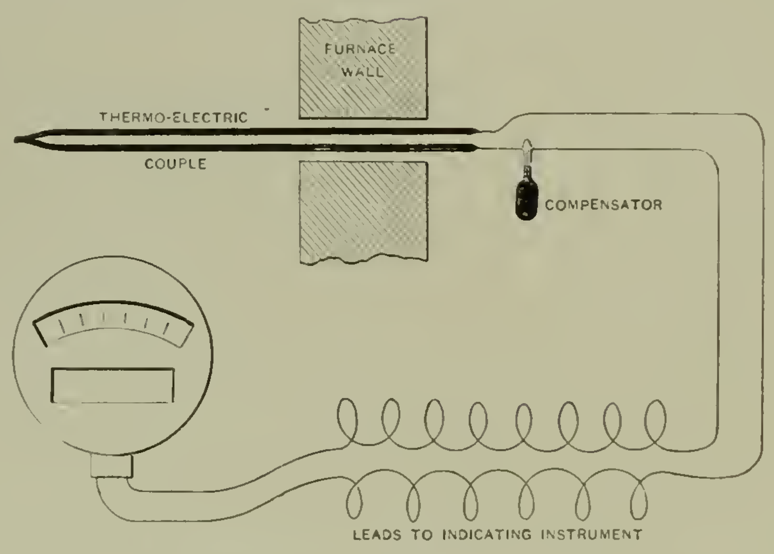


FIG. 9.—DIAGRAM SHOWING COMPENSATOR CONNECTED IN THE CIRCUIT

For this purpose the couples are protected by wrought iron pipes and will last for months without renewal. After constant daily use for many weeks the couples give the same readings as when first installed.

In addition to making it possible to obtain absolutely uniform results with a given lot of steel, it has been found that the life of the pots has been increased, as they are not overheated. From this fact it naturally follows there must be an economy of fuel as a result of using the pyrometer.

Application has also been made to galvanizing baths, affording means for keeping the molten metal at the proper temperature for the work, preventing overheating and wasting of zinc by vaporization.

They have been used in the manufacture of shot to keep the molten lead at the correct temperature.

These instruments have also been tried and are now being tested for indicating the temperature in the carbureter and superheater of a Lowe water-gas plant.

Where the process of gas making depends upon proper temperatures, the pyrometer shows when the steam and oil should be turned off and the blast turned on, and also when these operations should be reversed in order to obtain the most efficient results.

By using two or three couples in the carbureter, it is possible to adjust the spray of oil so that every part from center to shell will be working to the best advantage.

The instruments have also been successfully employed in chemical works.

The field of usefulness seems to be very broad, as the instrument can be adapted to meet almost any individual requirement.

After the reading of Professor Bristol's paper, the following communication was read from R. L. Penney, engineer in charge of testing and experimental work of the Winchester Repeating Arms Co., of New Haven Conn.:—

"In manufacturing fire-arms it becomes necessary in many cases to be able to determine quickly the temperatures of baths, furnaces, etc. The first kind of pyrometer used by us was that made by one of the well-known companies, but we soon found this kind to be as variable as the weather, and not to be depended upon for anything like accurate work.

"The Le Chatelier was then tried and found to give excellent results, but it was too delicate to be generally employed for shop use. It required a rigid foundation, and even then the fibre for suspending the needle would break occasionally. Trying to keep the temperature of the cold junction constant or at 0 degrees C. was also very difficult.

"Beginning with last June, we have introduced the Wm. H. Bristol thermo-electric pyrometer and at present we are using it in four different branches of our work, hardening,

tempering, blueing and annealing, and are also using it in place of the Le Chatelier for experimental work. The results obtained so far leave very little to be desired. The instruments are arranged so that the workman knows just what he is doing and the element of doubt and uncertainty is eliminated.

"The hardening furnaces each have a couple, a compensator, and a set of leads, while one instrument does for all. The instrument is placed on the wall in a place convenient for all the workmen, and near it is a small switchboard containing a switch for each furnace, the switch having a common connection to the instrument. The leads are brought from the several furnaces to the individual switches, the furnaces and switches being numbered to correspond. A workman, we will say, is working on No. 4, and is required to keep his furnace at a certain temperature. He goes to the switchboard and throws in No. 4 and reads the temperature directly, without making any correction, and without waiting for an oscillating needle to come to rest. The couples are introduced into these furnaces from the back, the fire ends being enclosed in a porcelain tube. These couples have required no attention since they were set up. The same scheme is applied to our tempering and blueing baths, using a lower range instrument. In these applications accuracy and permanency are very essential points.

"With these pyrometers as now in use we are enabled to obtain results that are unchanging from day to day. In annealing, they are of great benefit. On account of the inexpensiveness of the couples we use two for each furnace, one to measure the temperature of the furnace and another to measure the temperature at the center of the box containing the work to be annealed. The leads from each couple are carried to a double-throw switch. The workman in charge throws the switch one way to find the temperature of the furnace and the other way to find the temperature of the work.

"The two couples are introduced together through the side of the furnace, one reaching into the furnace a short distance and the other extending through the fire space into the center of the box through a hole in its side. This arrangement has been found to be satisfactory and enables the workman in charge to handle the furnaces as if they were machines, slacking and starting them up as necessary.

"Having compared the Bristol pyrometer with the Le Chatelier and finding the Bristol to be accurate, we have used it for experimental work in many cases. Wishing to determine the rate of the rise of heat in a case of cartridges and the temperature at which they would explode, when heated gradually from the outside, two couples were introduced into the case, one a short distance and the other into the center. The instrument was about 90 feet distant and heat was applied to the outside of the case, which was enclosed in a sheet-iron oven. The heating continued until all the cartridges had exploded.

"The cartridges exploded one by one, there being no general explosion. On examining the couples after the explosion they were found to be bent and twisted out of shape, but no indication of this was shown on the instrument during the experiment. Anyone looking at the instrument would not guess that the couples were being used so roughly. The temperature rose steadily to a maximum and then dropped. If it had been necessary to use two platinum-rhodium couples this would have been an expensive and difficult matter.

"We have found the Bristol pyrometer to be one that can be applied to every-day shop problems successfully."

Lightning Protection for Electric Railways

In a recent address before the New England Street Railway Club, at Boston, H. W. Young, of the Boston office of the Westinghouse Electric & Manufacturing Co., said that plans for the installation of lightning protective apparatus for railway systems should not be decided on until the location of stations, lines and apparatus had been definitely determined.

It is a most serious mistake to complete plans for power stations without any regard for protective apparatus, for this equipment requires space for insulation, ventilation and accessibility. The location of lightning arresters should be such as to provide each separate line leaving the building with one arrester having a voltage rating slightly exceeding the voltage existing between line and ground when one of the wires of the system is grounded. This excess rating may in some instances vary from 25 to 100 per cent. greater than normal. Relatively heavy insulators should be used in cases where heavy thunderstorms and strong winds are frequent.

If high-voltage generators supply the line directly, without stationary transformers, still greater care becomes necessary in the choice of arresters. Since the value of protection afforded in any case is directly proportional to the difference in resistance to static charges offered by the protective device and the apparatus it is intended to shield, preference should be given to those devices offering the lowest equivalent spark gaps. These spark gaps should be considerably lower in value than the impedance of the protected apparatus. The lowest equivalent air gap is that gap in inches which, when placed in multiple with the arrester, will just fail to take the discharge.

A choke coil impedes the free passage of static discharges, but a lightning arrester should offer a very free path. In the absence of suitable arresters on a railway line, the static discharge is liable to all pass through a motor armature, probably puncturing it near the point of entry of the static discharge into the coil, and often followed by a line current capable of seriously injuring the armature. The insulation of old apparatus is much more difficult to protect intelligently by arresters than that of new equipment, for there tends to come a time when the insulation is so poor that it affords a freer discharge path than the protective devices themselves. The ideal lightning arrester would require an equivalent spark gap of zero, allowing a static discharge to pass through it with absolutely no opposition. While this condition is not to be obtained in any commercial arrester, the advances in design tend toward a point where the freedom of discharge may be reasonably satisfactory.

The multigap arrester with series resistance pencils depends for its action upon the ability of the resistance pencils to suppress any short-circuit current which may follow a static discharge. A second type is the multigap with non-arcing metal cylinders arranged on the "low equivalent" principle. This type has the lowest equivalent spark gap of any arrester for the service for which it is designed, and an instantaneous current carrying capacity, which, while not affecting the normal operation of the system, materially aids in clearing the line of disturbances. It is specially effective in effacing surges due to grounding, short circuits, etc. The discharge also takes place too

quickly to open the circuit breakers on systems where they are tightly set.

The horn type of arrester requires some additional resistance to cut down the flow of current on short circuits in order to preserve its life; even then its action is so slow as to impair its usefulness in railway work, and for indoor service it is a very undesirable type. The resistances so far used with this type have proved to be of very doubtful value.

It is generally agreed that choke coil protection is necessary in every progressive installation. Either the static interrupter or the simple choke coil may be used in high work. The former is applicable only on the terminals of apparatus between the switches and the equipment protected; the latter may be placed directly in the line leads or in the terminal leads. The placing of coils in the line leads does not allow as economical an expansion of the station or as good protection against switching strains as when the coils are placed in the leads of the apparatus. The static interrupter differs from the choke coil in the addition of a condenser between the coil and the apparatus protected. The condenser has the effect of increasing the speed of a high-frequency discharge's entrance into the choke coil, with the result that the coil chokes back even more violently on account of the increase in its effective impedance.

It is very important, however, to protect impedance coils against side flashes, extending the insulation between layers far enough beyond the wire to form strong barriers. The same construction is used with oil-immersed choke coils.

Considering low-tension protection against lightning, as in feeders, trolley circuits and cars, arresters should be located so as to protect the cars rather than the feeders. Experience shows that 5 or 6 arresters per mile will usually be satisfactory. Every car should also be equipped, even though the line may be, because any apparatus connected to the line shares with the arresters in clearing the line. The forms most generally used are the moving plunger type, the magnetic blow-out, and the fixed coherer type.

An effective form of arrester for 500-volt station series consists of a set of choke coils connected to carbon electrodes immersed in a tank of water. This provides a good path to earth, although it is the cause of considerable line leakage.

Many inherent failures heretofore ascribed to defective protection have now been almost eliminated. Although much has been done, we are still ignorant of the quantitative measure of the forces to be dealt with. This knowledge can be obtained in large measure by the cooperation of operating companies at large. On many railway systems of the first importance we find lightning arresters of the most antique design. In many cases leads are burned off or grounds poorly made; bad rail bonding frequently occurs, and this where the rails provide the only path of discharge to the earth. No regard is given to the system as a whole, and the question of lightning protection is given a haphazard and indifferent attention which does the operator no good and throws most unjust criticism on the manufacturer of protective apparatus.

Of all disturbances to a system, that from lightning is doubtless the most unwelcome. It is not present the whole time and varies greatly in intensity from storm to storm. Considering the exceedingly moderate cost of protection, it is singular that so little is done. Every railway should place the matter of lightning protection in the hands of a special man, preferably a technical graduate with some experience with one of the larger electric companies. His sole duty should be to map out the system, locate arresters, see that they are in first-class condition, make good grounds, use tell-tale boxes to record their operation, etc. He should report to the manager after each storm as to the damage done to apparatus, approximate loss of revenue, remedies applied, etc.

A profit and loss on this score would show some surprising results. Considering the losses entailed by armature breakdowns and repairs, the disabling of cars and derangement of schedules, the initial and maintenance cost of a proper lightning equipment would soon be fully warranted by the decreased repair bills, increased revenue and better service.

Cincinnati Chapter of the American Institute of Electrical Engineers

THE first monthly meeting of the Cincinnati Chapter of the American Institute of Electrical Engineers was held at the Grand Hotel, Wednesday, February 7. Prof. C. W. Marx, in discussing "Engineering Practice in Modern Hotels," said that he had visited the principal hotels and office buildings in New York and Chicago to see how successful the requirements at these places were met.

The proposition was presented to the local chapter to affiliate with the local chapters of the American Society of Architects, American Society of Mechanical Engineers and the Cincinnati Engineers' Club. The local chapter voted that it was the sense of the body to favor the affiliation. The articles of agreement provide that each organization shall retain its individuality, and that all the members of the affiliated bodies shall be invited to the meetings of each organization at which professional subjects are under discussion. It is intended to secure a suitable building at which all meetings can be held, and which shall be accessible to the members for informal meetings. It is further intended to create a library which shall be available to all the members.

The new officers of the local chapter are as follows:—C. S. Reno, chief engineer of the Triumph Electric Company, president; A. G. Wessling, engineer of the Allis-Chalmers Company electrical works, vice-president; Laurent Lowenberg, of the Reliance Engineering Company, secretary and treasurer.

Electric Traction in Lima, Peru

LIMA, Peru, is to have an electric traction system, using American electric apparatus and American railway materials entirely. The new lines will cover 30 miles, and will be in operation inside of twelve months. This is the first American electric traction system on the west coast of South America, British and German firms having hitherto secured all such contracts in that part of the world. The present mule lines of the Compania Ferrocarrilles Urbano de Lima are to be electrified, and several miles of new track constructed.

The contract for the entire work has been assumed by W. R. Grace & Co., of New York, and the General Electric Company, of Schenectady, N. Y., will furnish the large amount of electric apparatus needed. Forty-five motor cars of the open type of the summer car will be used. The car bodies will be built by the Stephenson Car Company, of Elizabeth, N. J. Electric power for the lines will be generated at a hydro-electric plant, 30 miles from Lima, on the Rimac River.

The production of copper in the United States increased from 817,715,005 pounds, valued at $106,320,950, in 1904, to 925,267,840 pounds, valued at $145,257,798, in 1905.

From the World's Technical Press

Standardization of Wireless Telegraphy

STANDARDIZATION of electrical machinery and apparatus is freely discussed, but in some branches of the industry there has not been the slightest attempt at standard forms and measures of efficiency. Space telegraphy, says the "Western Electrician," is one of these departments. It is true that "wireless" is difficult to standardize, but it does seem that in the eight years that various forms of this invention have been in commercial use some attempt might have been made to arrive at some common measure of accomplishment.

The wide variation that exists in the methods and expense of doing the same thing is strikingly shown when manufacturers of space-telegraph apparatus are invited to submit bids for supplying a certain installation. If it was generators that were to be supplied, for instance, a certain range of variation would be looked for in the tenders, but one would be utterly at a loss to understand how one bid on a set of specifications could be forty times as large as another. And yet that is what was disclosed, apparently, when bids were recently opened by the Navy Department for furnishing ten sets of space-telegraph apparatus for the navy, intended for stations mainly on the Pacific coast. The propositions received, as to price, were $9468 from the lowest bidder, ranging through $15,000, $25,100, $48,300, $67,950, $175,600, to $393,500. The contract was awarded to the next to the lowest bidder, so that the highest two bids were evidently excessive, not to say wild.

The discrepancy between the prices asked by different companies for space-telegraph apparatus has been noticeable in competitive bids heretofore, and it indicates that, aside from the difference in price which would naturally arise from differences in the nature of the apparatus, manufacturers have nothing in the shape of a common standard. Of course, systems will differ in various particulars; but of two equipments, each guaranteed to carry on communication for 100 miles at sea, we will say, there can be no possible reason why one should cost forty times as much as the other.

Engineering Precedents

THE practice of the profession of law consists largely in conforming to a systematic mass of court decisions carefully recorded so as to show the special conditions and general legal principles affected. The citation of the decisions of cases in the courts of last resort, similar to or identical with any case in question, is considered conclusive as to the results of litigation.

Regarding these general features of the practice of law, "The Engineering Record" remarks that they hold in spite of the fact that occasionally a court of last resort may reverse a preceding decision, nor are they inconsistent with the fact that new decisions may be expected at any time. The practice of civil engineering, on the other hand, is in some respects directly opposite in its features to that of law. Some of the most accomplished practitioners in engineering at times pride themselves upon having violated precedent by the adoption of new methods or new materials, or in some other essential way, in the successful prosecution of their work. It is not possible that there should be courts either of the first instance or of last resort in the practice of engineering. The works to be accomplished are based on methods and materials subject to constant development and occasional radical change.

There are many circumstances under which the engineer may fortify himself by the example of works already accomplished under conditions more or less similar to those constituting the environment of a new work to be undertaken; or proposed methods or materials may receive professional disapproval for the reason that similar results have not previously been accomplished. It is within the experience of every engineer of extended practice, however, to have observed that such conservatism not infrequently results in either unnecessary cost or diminished degree of excellence. In fact, an engineer possessing an aggressive professional temperament and fertility of resources must frequently strike a judicious balance between novel procedures and engineering precedent. While he must have due respect for that which has been accomplished, he must at the same time be resolutely pushing ahead of precedent to establish new high-water marks of attainment in engineering work.

These general propositions will scarcely be controverted by any professional engineer, but there may be a justifiable difference of opinion as to the extent to which any engineer is justified in being governed by them under given conditions. In projecting any great work it is always necessary to make a decision between the use of grades of material hitherto used for the same purpose and improvements in them more or less radical, and it is occasionally essential to make a similar choice in methods of procedure. The conservative mind seeks the assurance to be derived from following those things which have already been successfully done, while the alert and more vigourously progressive individual endeavours to establish new grades of excellence and new methods of attaining them.

There are engineers of repute and of long experience who decline even at the present day to use masonry

instead of more expensive ashlar where the majority of engineers would not hesitate to use unlimited masses of the more economical material. Again, it was but a short time ago that a distinguished engineer in American practice opposed the use of concrete in a great work, where it was subsequently most successfully employed, on the alleged ground that it could not be given an enduring surface. Similarly, it was only two or three years ago that the use of nickel steel in the eye-bars of a proposed great bridge structure was opposed in emphatic terms by many engineers on the ground that that material had not yet been sufficiently tried to give a proper degree of assurance as to its adaptability to the structure in question.

It is beyond all question that the judgment of the engineer must be his guide as to the adoption of new materials and procedures in violation of precedent, but there are certain general principles involved which should be respected and do not trench upon the proper use of precedent, nor stand in the way of progress. It is obvious that experimenting by a young engineer, for instance, whose judgment has not been trained by experience, is likely to bring financial loss to his client and prejudice to his professional standing. The young practitioner may, to a greater extent than the older member of the profession, follow somewhat along the lines of his legal friend. Accomplished work may suitably be a guide. In fact, experimenting in practical work, except when directed in general by engineers of educational training and experience, is apt to be hazardous. On the other hand, that kind of violation of precedent which follows from rational professional development, to the extent of displacing familiar methods or materials, is not only justifiable, but highly desirable. It is only through such rational and well-directed development, based sometimes largely upon full-scale experimenting, that the best and most healthful engineering advances are made.

Any engineer who declines to use such a well-tried material as concrete and involves his client in large additional and unnecessary expense in consequence of simple professional inertia, is falling far short of serving his client with the efficiency and excellence that ought to characterize a high grade of engineering work. A well-balanced construction, whether of a structure or machine, based upon the ground principles of engineering science and adapted to the actual conditions of practice, need not be characterized by any degree of imitation of what has been done before. It may be new in every feature and yet be as fully justified as if the same thing had been done a hundred times before, provided the design and execution are based upon the broad general principles of similar practice. These general principles are not always easy to discover, but the degree to which they govern the advances in great engineering works is a measure of the professional capacity of the engineer who designs and executes them, irrespective of precedent or the dictum of pure authority. It must not be forgotten that in engineering as in no other profession, "the standard of to-day was the novelty of yesterday."

Electrically Welded Steel Barrels

THE making of electrically welded steel barrels by the Steel Barrel Co., Ltd., of Uxbridge, England, is described in a recent issue of "Engineering," of London. Current is supplied by a direct-coupled, continuous-current generator, with an output of 2100 amperes at 95 volts and 380 revolutions; and in view of the heavy current, the armature has two independent commutators, one at each side, and each connected to a separate winding on the armature. The two armature circuits are normally run in parallel, but, if required, could, of course, be put in series, converting the machine into a two or three-wire generator, with 190 volts across the outers. The chimney at the works is a standing advertisement of the company's process, consisting, as it does, of a steel shaft 56 ft. high and 4 ft. 6 in. in diameter, made of ¼-in. plates, having both horizontal and vertical joints welded electrically. The horizontal joints are stiffened by butt-straps welded over the junction of the plates. The chimney was erected by the aid of a derrick in about three hours.

In making a barrel, a rectangular sheet of steel is rolled into a cylindrical shape and the longitudinal edges are trimmed by shearing. It is then passed to the welder, who clamps it on an anvil with the joint uppermost and the edges about ¼ inch open. The anvil forms one pole of a 95-volt electric circuit, and a carbon rod, held in an insulating handle by the workman, forms the other. Small strips of steel, about 2 inches long and ½ inch wide, are laid over the joint, and an arc struck by the carbon rod. A few seconds suffice to melt a strip well into the joint, when it receives a few blows from a hammer, and is finished. The next strip is then laid on, welded, and hammered as before.

Each end of the barrel body having been slightly opened by a hand hammer, a flanged dish is driven in, with the flanged edge outwards and flush with the end of the barrel. Two thin strips of steel are clamped round the joint, one inside and one outside, and the four thicknesses thus formed are welded together by the arc. The other end is done in the same way. The bunghole is a steel stamping, which is placed in a hole punched to receive it, and welded in position. Another stamping, bearing the name of the owner of the barrel, is usually welded on the end.

The Manufacture of Steel in the Electric Furnace

THE smelting of iron ores by electrical methods is being seriously considered in those countries where there are no iron blast furnaces, yet where sufficient quantities of iron ore exist to make the new process an attractive one. The western parts of the United States and Canada are regions of this nature.

Commenting on the report of Dr. David T. Day, of the United States Geological Survey, which gives the results achieved in recent experiments made with magnetic iron sands in the electrical furnace at Portland, Oregon, the "Mining and Scientific Press" says that while the results must be gratifying to those connected with these experimental operations, it still remains to be seen whether or not they will be of immediate commercial value. The making of steel direct from iron ore, by this process, is still in its infancy, and while encouraging results have been obtained in an experimental way both in the United States and abroad, it is still too early to look upon these experiments as anything else than an illustration of the possibilities of the future in this direction.

As an outcome of the success attending these efforts, numerous electrical smelting companies—"which promise to revolutionize the iron industry,"—have recently come into existence, and capital is being solicited to engage in electric smelting with every assurance by the promoters of success. A few months ago the radium promoter had the field, but that fad, failing in the production of promised immediate results, has dwindled and almost dis-

appeared, and the commercial world goes on its way undisturbed by the promised vast production of radium which never materialized.

With electric smelting, however, it is somewhat different. A very high grade of steel has been successfully produced by this method, and when the process and its limitations are better understood, its value commercially can be more fully estimated.

At present, at any rate, it can only be hoped that the manufacture of steel in the electric furnace may become a commercial as well as a technical success, where transportation of steel, made by the usual methods, is such an important factor that the electrically produced steel will become a successful competitor.

Electric Drive in Locomotive Repair Shops

WRITING on the above subject in "Railway and Locomotive Engineering," A. S. Atkinson says that the question uppermost in the minds of engineers and operators is the more complete equipment of the shops with machines that will show definite results.

In the daily operation of a repair shop the full capacity of the engines and motors is rarely approximated,—usually half of the possible maximum total of power is the average consumed. The ratio of the load factor to the maximum power must be considered in estimating the cost of the work. The number of tools that are either standing idle or working under light loads is always sufficiently great to secure for electricity an advantage that in the aggregate amounts to a considerable sum in the course of a year.

The ability to secure actual data in regard to the amount of power used for driving various individual tools and machines by electricity has proved of inestimable value to the operating engineer. By means of a voltmeter and an ammeter in the motor circuit, exact measurements of the power delivered to each motor for driving a tool are obtained, and the question of loss and inefficiency of any part of the equipment is easily solved. The actual economy found in an electrically driven repair shop is thus very striking, owing to the saving of power when some tools are idle or running lightly, and to the fact that unprofitably operated machines can be quickly singled out and repaired or displaced.

In the large car shops of the Buffalo, Rochester & Pittsburg Railway Company, at Du Bois, Pa., the electrical drive has now been in use for upward of two years, and the results obtained have demonstrated some of the high efficiency and economy of electric operation. The plant was one of the first in the field of electric equipment, and its completeness is unusually satisfactory. Starting in with an equipment sufficient to handle the repairs of 150 locomotives a year, with a further extension that will shortly bring the total up to 225 locomotives a year, or about 18 locomotives a month, the shops have yielded results up to date that are of special significance.

By adopting the central power system, the machine, boiler and tank shops are under one roof, and electricity is distributed from this building to the various units of the plant, including the blacksmith shop, roundhouse, office and store-house, and oil-house. The extension of the works is made comparatively easy by the simple addition of new buildings, for the power capacity has been designed for increasing the demands of the plant in the future. The central station or power-house furnishes all the electricity and compressed air for driving all the machinery, lighting the different houses, operating fans and blowers, and other mechanical work. The wires for transmission of electricity are carried in underground conduits to the different buildings, and there is no obstacle to restrict free operations in the yards between the buildings.

The exact data obtained from reading the meters for the different machines enable the engineers to figure out the relative cost of running the various groups and single tools in the shop, and as such they furnish the basis for future improvements in the interests of economy. Furthermore, the indications are that the grouping of different machines on line shafting is a matter that may yield much higher results than formerly. The maximum power required to start up some of the heavier machines, and the great consumption of power by the planers at reversal, show that these machines if all grouped on one line shafting might overload the motors to such a degree as to cause trouble if they were started up at once. The grouping of some of the smaller machines on the shaft with the larger ones, on the other hand, adds so little to the load that they prove of no importance in the general operation of the motors. Such slight additional loads thrown on the shafts, even when running at the maximum load of the larger machines, scarcely affect the ultimate results.

The modern designing of locomotive repair shops is one of the questions of the day which concerns railroad companies, and since the electrical drive has come to stay, it is important that data concerning the operation of the tools and machines be obtained to indicate the most economical and efficient grouping of the machinery under one roof. The modern repair shop of a railroad is often the place where the question of profit and loss is decided, and its efficiency must be paramount.

Brittleness in Steel Caused by Electroplating

IN discussing the injurious effect of acid pickles on steel in a recent issue of "Electrochemical and Metallurgical Industry," Prof. Charles F. Burgess said that steel springs, such as are used in locks, clockwork mechanisms and the like, steel tapes, piano wire, and many other tempered steel articles, having but a small section dimension, cannot be subjected to the ordinary plating process on account of the deterioration which takes place in the metal.

In pickling steel, the resulting brittleness seems to be caused by the hydrogen liberated. The view is also held, however, that the acid itself penetrates into the metal through capillary or other force, the destructive action being thus continued after the metal has left the pickling solution.

That hydrogen has a capacity for exerting a marked influence on the properties of iron is demonstrated in the electrodeposition of that metal. The iron thus produced has associated with it, either in chemical or physical combination, a relatively large quantity of hydrogen. The gas may be expelled by bringing the metal to a red heat, but this expulsion involves a change in the property of the iron, which from being hard and brittle becomes soft and ductile. An apparent anomaly is the fact that steel possessing certain physical properties may be exposed to hydrogen gas under vaying conditions of temperature and pressure without undergoing any material physical changes and without absorbing any appreciable quantity of the gas. If, however, the metal is exposed to hydrogen under that peculiar condition of activity commonly known as the nascent state, the absorption of hydrogen becomes most marked. The action of acid upon iron liberates hydrogen in this peculiar condition of activity, and

the iron therefore absorbs the gas.

Tests were made to determine whether or not the deterioration in nickel-plated iron and steel articles was caused by the preliminary pickling process. Three samples of spring steel were prepared for receiving a nickel coating, the following methods being employed:—Sample No. 1 was freed of scale by rubbing it with emery cloth. No. 2 was pickled in the ordinary sulphuric acid solution. No. 3 was immersed in a pickle of similar nature, to which had been added a small amount of arsenious acid. The samples were then plated in the nickel ammonium sulphate solution and were tested.

Sample No. 2 showed the greatest amount of deterioration, and while the deterioration of No. 1 was less, yet it showed an appreciable weakening, demonstrating that the nickel plating solution in itself exerted a harmful effect on the thin steel strip. This was due, possibly, to the presence of a small amount of free acid in the solution. Whether a neutral solution would show the same effect is a question that was not put to test at the time, but it is probable that such an investigation would be of interest, and, perhaps, of some practical importance. The sample which had been subjected to the pickle containing arsenic was weakened materially less than the piece which had been cleaned mechanically, and whether the arsenic not only decreased the harmful effect of the pickling solution itself but also that exerted by the plating solution, or whether the results as given may be traced to inaccuracies in the experiment, it is impossible to state without further investigation. There seems to be little doubt, however, but that the entire nickel-plating process produced harmful effects in certain classes of work, where the section of the metal treated is so small as to make the affected part a considerable percentage of the whole.

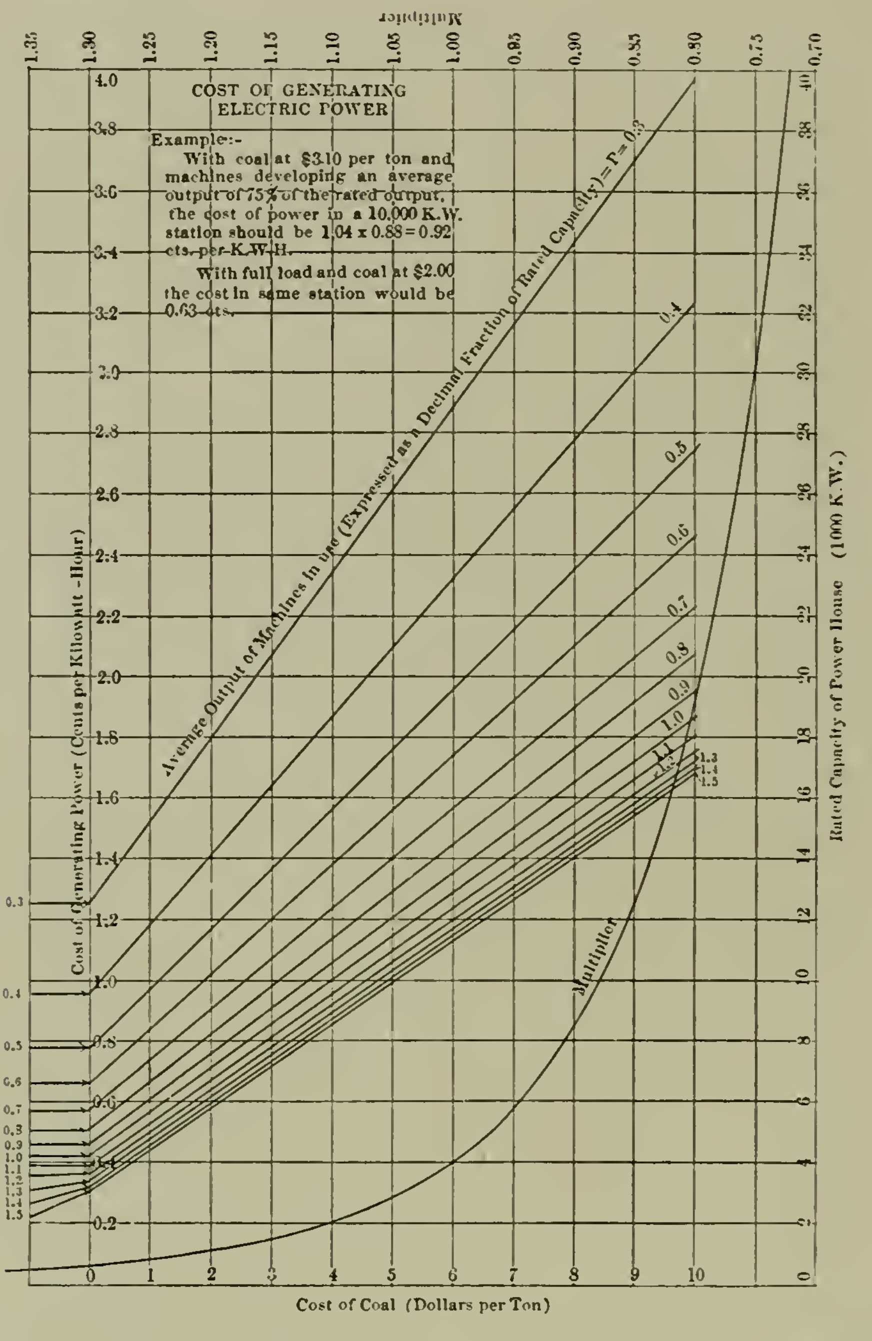
Cost of Generating Electric Power

THE cost of power is dependent upon so many variable and uncertain factors that it is impossible to arrive at any theoretical results which will be strictly applicable to individual practical cases, but it is possible by making certain assumptions to calculate a series of cost curves which will approximately represent the cost of power per kilowatt-hour under various conditions and whose relative values will be fairly reliable.

F. A. Griffin has followed this plan, and gives in the "Street Railway Journal" the following curve sheet from which may be found the cost of generating electric power in stations ranging in capacity from 400 KW. to 40,000 KW. The cost of power expressed by the curves is intended to represent the cost which can be obtained commercially in a well-designed station with a reasonably efficient operating staff.

The use of the curves may be illustrated by solving an example. Let it be required to find the cost of generating power at a station whose rated capacity is 10,000 KW., the average load on machines in use being 75 per cent. of their rated output and bituminous coal costing $3.10 per ton. Following up from the lower horizontal scale to a point about midway between the straight line marked 0.7 and the one marked 0.8 over the point corresponding to $3.10 per ton, the figure 1.04 is found on the left-hand vertical scale. Following to the left from the right-hand vertical scale along the 10,000-KW. line to its intersection with the curve marked "multiplier," the figure 0.88 is read upon the upper horizontal scale. The product of the two figures thus obtained, 1.04 times 0.88, gives 0.915 cent per kilowatt-hour as the probable cost of power.

If the average output of the machines in use is equal to their rated capacity, and coal can be had at $2 per ton, the cost of power would be only 0.63 cent per kilowatt-hour.



CURVE SHEET FOR FINDING THE COST OF GENERATING ELECTRIC POWER

Electrically Driven Rolling Mills

ALTHOUGH electric driving has been adopted in many industrial operations, yet, says Ralph W. Birkett in "The Engineer," of London, there are few examples, in Great Britain at any rate, of the application of electric motors to the operation of the heavy machinery of steel works, such as the mills for rolling bars, angles, plates, and rails.

It is, indeed, only within recent times that motors capable of developing the large powers required in such work have been shown success-

fully at work for other purposes. This, in conjunction with the rarity of new installations of rolling mill plant, has prevented the rapid development in this particular branch, which electrical driving has achieved in other departments.

The question of its adoption would be worth considering in the case of extensions to existing, or the laying out of new plant; and especially if it were intended to make use of blast furnace gas as fuel, or producer gas for gas engines to run the generators. It is even open to argument whether many of the existing plants could not be rearranged for electrical driving, so as to show improved results. The electrical engineer, while he would have no hesitation in tackling such work, is not yet, however, equipped with the array of facts and figures, drawn from his own experience, which he is expected to show when the electrical driving of rolling mills or other machinery is discussed.

There are really no great difficulties to be overcome in the electrical driving of rolling mills. Although a mill may offer, perhaps, as awkward a load as any generating plant could be called upon to deal with, a system including a battery and automatic reversible booster will enable the engineer to undertake such work without fear of trouble. Other machinery, presenting loads of similar character, such as colliery shaft winding, haulage, etc., can also be undertaken, and while helping to improve the load factor of the plant, cannot have a prejudicial effect upon the steadiness of other work.

There are many branches of manufacturing industry wherein electrical power has not yet secured a foothold, but if electricity can be successfully used in such work as rolling mills and incandescent lighting mixed, there should be few processes to which it cannot be applied as motive power. The most economical power generator for a steel works would probably be engines using waste or producer gas. These providing electrical power for all purposes of the works could, as a number of, or single units, be run always at their highest efficiency. Generating direct current at 500 or 600 volts, economical transmission may be obtained, and power applied at this pressure direct to every kind of machinery. With a battery and booster perfect governing of the system is effected, and maximum economy of operation secured.

It has been calculated that, taking high-pressure, three-phase current from supply mains for rolling mill work for each horse-power-hour used in rolling work, 2 H. P.-hours must be generated at the power station. This is largely accounted for by the losses in the regulating and converting machinery, between the supply mains and the mill motor, which cannot well be avoided if power for other work is to be taken from the generators feeding the mains.

It would appear, therefore, that in any case it should be more economical to generate direct current on the spot, as by the use of battery and booster no interference with other work need be feared, and the only loss would be the difference in the efficiencies of the battery and an engine of equal power. Even this will be overbalanced by the economies in the general efficiency of the station which the regulation of generator load by the automatic action of the battery will effect, providing, as it does, for the peaks, and storing up the surplus power of the engine not required by the mains at times of light load.

Underground Telegraph Wires

UNDERGROUND telegraph wires between cities would afford the great advantage of uninterrupted service, no matter how severe the weather conditions. Nearly every winter the newspapers give reports of storms, with "wires down in all directions." This interruption of service between Chicago and New York, for example, is a very serious matter, and underground circuits would obviate the trouble. Several practical objections to this scheme, however, are noted in "The Western Electrician."

One objection would be the great expense. It would be desirable to lay the wires in iron pipe, and this pipe alone would cost between $1000 and $1500 a mile, or over $1,000,000 for the distance between the two cities mentioned. Then there would be the cost of trenching, the building of manholes, the insulation of the wires or cables, and other items of expenditure. It is probable that the interest on the money invested in such a line would exceed the annual cost of repair to a corresponding overhead line, heavy as the latter item is.

Another objection to the underground wires exists in the fact that owing to the retardation in a buried cable, as compared with bare wires in the open air, the circuits would work more slowly. With good weather conditions the free wires on poles give better and quicker service than the cables.

The underground alternative is one that has been given considerable attention by telegraph engineers, and several years ago C. M. Baker, superintendent of construction for the Western division of the Postal Telegraph-Cable Company, made some tentative estimates on the cost and practicability of underground telegraph lines between Chicago and Toledo,—a distance of about 200 miles. If the idea should be adopted, Mr. Baker advocated iron pipe laid 3 feet below the surface of the ground, and he showed the necessity of manholes at regular intervals and the desirability of utilizing a level right of way, such as that of a railroad, rather than going up hill and down dale with the trench, following the contour of the country. But the idea was not considered practicable, and overhead wires still convey the telegraphic messages between Chicago and the Ohio city.

In England there are a few long underground telegraph circuits, although in that country also the greater part of the cross-country construction is overhead. In large cities, of course, both in England and the United States, the telegraph wires are carried beneath the ground.

Electrolytic Rectifiers for Telephone Stations

ACCORDING to "Engineering," of London, electrolytic rectifiers are now being used for working telephones with rectified three-phase currents of 120 volts. The rectifier consists of four cells with stamped sheet-iron cases, in which aluminium electrodes are suspended. The electrolyte is a sodium salt: sodium sulphate and sodium phosphate are, as a rule, used.

The cells are coupled in such a way that all the positive and negative-current impulses from two of the bus-bars are combined to give a direct current of fairly constant voltage about 20 volts. The cells have a resistance of 320 ohms, and require a "formation" before use.

When the current is first switched on, eight incandescent lamps, in series with the cells, flash up; after a few minutes their glow will have diminished to dark red, and the telephone circuit can be closed. The current then passes from the one bus-bar to a transformer, and back to the other bar, while a branch current flows through the rectifier and returns through a resistance of 1600 ohms. This branch comprises a split battery of four accumulators, which feed the signal lamps coupled to the relay contacts of the connection of the telephone switchboard.

The cells must be refilled occasionally, this being necessary when the resistance lamps continue to shine brightly instead of toning down; the aluminium electrodes must then be cleaned of crystals and the cells recharged with fresh electrolyte, the salt being dissolved in distilled water. An efficiency of 70 per cent. is claimed for these rectifiers, but they have not, so far, been regarded with much confidence, because the aluminium electrodes do not last long.

Gas or Electric Motor for Roll Driving

ROLL trains are classed in three categories by Carl Ilgner, in "The Iron Age," according to the manner in which the power for driving them is utilized. His classification is:—1. Reversing mills. 2. Trains always running in the same direction, but at a speed varying from time to time in the ratio of 3 to 2, while the slowest speed corresponds with the greatest absorption of power. 3. Those in which both power and speed are constant.

For the first of these classes the gas engine is inapplicable, notwithstanding the attempts made at various works to introduce a reversible coupling between the fly-wheel and the roll train. Electric driving affords excellent means not only for easily and certainly regulating the speed, but also for transforming the variable power required by the roll train into one that is almost uniform, in which case there is no doubt of the success of electric driving. Several electric roll trains are under construction, and the preliminary trials hold out the hope of thorough success.

If a roll train, the speed of which varies periodically, be coupled with a gas engine, the latter will furnish the greatest amount of power when the speed is lowest. But the products rolled at this slight speed only constitute a third of the whole output, while the remaining two-thirds will be rolled at the maximum speed of the gas engine, the efficiency of which will be very slight. It follows that the gas engine will give out a considerable portion of its power while consuming too much gas per horse-power hour. By employing electricity as an intermediary, the variations of speed are transferred to it so that variation of the load on the motor is diminished. The consequence is that, notwithstanding loss in the electric transmission, and without regard to variation in the speed, gas engines that are no more powerful than those for driving the roll directly may be erected at the generating station.

It is perfectly evident that reversing mills and cogging trains absorb a widely varying amount of power. Electric driving and centralizing the generation of energy, present excellent means for regulating motive power, on the one hand by increasing the rotary masses in motion, to which are added those of the fly-wheels at the generating station, and on the other by distributing the shocks and the irregularities over the whole generating station. It is evident that the power thus required by the cogging rolls from the gas engines at the central station will be less than that which the rolls would absorb if each were driven directly by its own gas motor.

As regards the third class,—roll trains of constant speed, which are generally used for plates and small bars, variations of load are not considerable, and in their case electric driving does not afford any great advantage. If, however, it be required to drive roll trains of all three classes, there is no doubt that centralization of the power is preferable to the use of a gas engine for each separate roll train. And to the advantages already claimed for the electric driving of roll trains in classes 1 and 2 must be added those resulting from centralization of the power. The total power absorbed by all the roll trains at a given moment is undoubtedly far less than the sum of the maximum power required by each train.

Another advantage is that the motor of the generating station can receive all the care it requires, because one can be kept in reserve. If the gas engine be coupled directly with the roll train, the stoppages required for overhauling will not be compatible with the proper working of the train. The electric motor stands overloading better than does the gas engine, while it can be replaced by another of greater power more easily and at less expense. The provision of a reserve for meeting hitches at the blast furnaces or coke ovens is easier at a central station than for each motor. In the latter case all that can be done is to lay down gas producers more difficult to manage, owing to intermittent working. At the central station, on the contrary, a steam turbine with a bank of gas-fired boilers constitutes a trustworthy reserve.

In short, a whole series of weighty considerations count in favour of centralization. If it be considered that at the central station much less power plant will need to be laid down, while larger motors may be employed, and if again the connections of each train and the long gas pipes be considered, the conclusion is warranted that the first cost will not be an obstacle to adopting the principle of central electric stations. The difficulties encountered in the progressive transformation of works must not be disregarded, but it appears undeniable that centralizing the motive power of rolling mills, with electric driving and the use of blast furnace or coke oven gas, give promise of great economy as compared with present practice.

Transmission of Musical Tones by Telegraph

THE transmssion of musical tones by telegraph is described by a correspondent in "The American Telephone Journal." The phenomenon occurs occasionally in telegraph offices under favourable conditions, and accidental reproduction of speech by telegraph instruments on composite circuits is not unknown. The correspondent writes as follows:—

"Several days ago I was sending music from a phonograph out over a telephone line by means of having a transmitter fastened to the mouth of a large megaphone; this in turn was hung over the horn of the phonograph. I sent the music to several stations very well. I then thought of sending it out on our telegraph line in some way, and upon experimenting found that we could do it very nicely by cutting out the line relays and adjusting the sounders very closely, so it practically acted as a receiver, the apparatus at the phonograph having first been switched over to the telegraph line.

"By this method of working we could furnish very clear music to all the telegraph stations. I arranged a signal with them, so that when I rung out on the line with the telephone generator, which would work the relays, they were to cut relays out and put in sounders and adjust them down. I then put in a knife switch over the telephone, having the telephone on the center, telephone and telegraph lines on the respective ends, so I could thereby supply music to either line any time—the sounder would reproduce voices very clearly as well as music."

The City Council of Chicago has passed a resolution demanding that the Illinois Central Railroad electrify its line within the city limits.

Pipes and Joints for High Pressures

By FRANKLIN RIFFLE

A Paper Read Before the Technical Society of the Pacific Coast

THE tendency of the times is to use higher pressures for the transmission of water, steam, and gas, thereby reducing unit costs. On the Pacific Coast conditions are exceptionally favourable for utilizing water under high heads, in order to manufacture comparatively cheap power. During the past ten years California engineers have had the good fortune to design and construct a number of high-pressure plants, and incidentally to contribute much valuable experimental knowledge to the science of hydraulic engineering.

The subject is of vital concern to the engineer, for upon him devolves the responsibility of selecting, with intelligent discrimination, the class of pipe and design of joint that are best adapted to meet the conditions confronting him—having due regard for stability on the one hand and economy on the other. To combine properly these two functions often calls for the exercise of engineering knowledge and skill of the highest order.

The object of this paper is to discuss, as concisely as possible, the several types of pipes and joints that have recently been used for high pressures, with special reference to Pacific Coast practice.

PIPES

On account of its high tensile strength, combined with other favourable physical properties, such as elasticity, malleability and ductility, steel is peculiarly adapted to withstand the stresses to which pipes are subjected when under pressure. Steel pipe, therefore, has been almost universally adopted for high-pressure work. While many engineers prefer cast-iron pipe for low pressures, on account of its extreme thickness and consequent long life, it is manifestly not adapted to higher pressures. No amount of care in the manufacture, inspection and testing can be relied upon to prevent pipes that are inherently defective from being accepted and used. Such pipes have been known to pass a rigid inspection, including a high hydrostatic test, only to crack in the most mysterious manner when subjected to a low working pressure. This is why steam engineers have discarded cast-iron pipe, and why hydraulic engineers, when dealing with pressures in excess of those ordinarily used in municipal water distribution, are inclined to use it with extreme caution. A notable instance of the use of cast-iron pipe for high pressures is in connection with the Colgate plant of the California Gas & Electric Corporation, where the maximum static pressure for 30-inch pipe is 305 pounds per square inch. In view of the general distrust, by hydraulic engineers, of this class of pipe for high pressures, it would be interesting to know to what extent the Colgate experiment has been successful.

STEEL PIPE MAY BE EITHER RIVETED OR LAP-WELDED

Riveted pipe is distinctly a California type, having been introduced into the State many years ago, when sheets of iron in stock sizes were brought from the East by sailing vessel to San Francisco, where they were cut to various sizes, punched, rolled and nested. In this compact shape sheets of the proper sizes were transported by water, wagon road and trail to the various mining camps in the interior, where they were riveted together. Even after the advent of railroads, riveted pipe continued to be used in California, almost to the exclusion of other types, chiefly on account of its relatively low cost. Increased transportation facilities, however, made it possible to have the pipe riveted into long sections in the well-equipped pipe shops of San Francisco, Los Angeles and Sacramento, a practice which prevails at the present time.

Riveted pipe is made into convenient lengths for handling (20 to 30 feet) by riveting together either conical sections or alternately large and small cylindrical sections, 3 to 6 feet long, each of which has a double-riveted longitudinal seam. The double rows of holes for the longitudinal seams and the single rows for the round seams are punched by power machines, and all overlapping edges are bevel-sheared. After the plates are rolled into cylindrical form and riveted, the seams are made tight by means of a pneumatic calking hammer operating against the beveled edges.

Butt joints with either one or two cover plates (the latter being presumably the stronger) are sometimes used for shells over $\frac{5}{8}$ inch in thickness. Outside cover plates are bevel-sheared and calked on both edges.

The efficiency of riveted joints may vary from 40 per cent. to 65 per cent. for single riveting, and from 55 per cent. to 75 per cent. for double riveting. As the strength of riveted pipe depends upon the shearing resistance of the rivets and the plates, and this, to a very large extent, upon the thoroughness with which the riveting is performed, it is apparent that rigid inspection during the progress of the work is essential, in order that the highest efficiency may be obtained.

In the manufacture of lap-welded pipe the longitudinal edges of each plate are scarfed, the plate is rolled in bending rolls until one edge overlaps the other, after which the skelp (as it is termed in mill parlance) is heated to the welding point in a welding furnace and then drawn over a mandrel and through a pair of rolls, the pressure of which on the lapping edges welds them firmly together. The welded joint has a much higher efficiency than the riveted joint, and presents the additional advantage of being as smooth as any other portion of the shell. Moreover, lap-welded pipe has no seams corresponding to the circumferential seams of riveted pipe.

Because of its superior welding properties, soft or mild steel is used by pipe manufacturers in preference to high-carbon steel. For screw-joint pipe Bessemer steel is preferred to open-hearth steel, owing to the difficulty of cutting perfect threads when the latter is used. When the ends of the pipe are to be flanged, open-hearth steel is preferred. When neither threading nor flanging is required, steel made by either process will answer equally well.

In high-pressure pipe lines used for water-power development it has been largely the practice in California to use riveted pipe at the upper end of the line, where the pressures are not excessive, and lap-welded pipe at the

lower end. Riveted pipe can be made of lighter plates than lap-welded pipe, which requires a minimum thickness of metal (varying with the diameter of pipe), below which the skelp will not retain its cylindrical form when exposed to the heat of the welding furnace. To illustrate: For 24-inch lap-welded pipe the minimum thickness of skelp that can be used is 5-16 inch, and for 26-inch pipe, $\frac{3}{8}$ inch, although the pressure conditions may be such that 3-16-inch shell will be amply strong. In the interest of economy, therefore, it may be found advisable in this instance to use riveted pipe; but when the computed thickness of shell is equal to or greater than the minimum thickness for lap-welded pipe, there is rarely anything to be gained by using pipe with riveted seams.

Up to the present time 30 inches (outside diameter) has been the largest lap-welded pipe made, and that only by one mill—the McKeesport Mill of the National Tube Company. But as preparations are now being made to manufacture 36-inch pipe, this size may be considered the maximum for lap-welded pipe. Therefore, whenever the desired volume of water is too large to be conveyed by a 36-inch pipe, it may be necessary to choose between two lines of lap-welded pipe and a single line of riveted pipe. The latter plan is evidently the more economical, although if the pressures are excessive there may be no alternative but to adopt the former, or at best a combination of the two. Thus it is obvious that each class of pipe has its advantages and also its limitations; and while there can be no question concerning the superiority of lap-welded pipe, the element of cost often operates to restrict its use to the highest pressures.

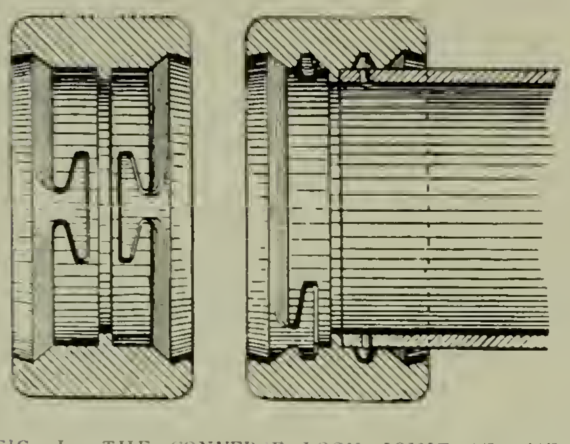


FIG. 1.—THE CONVERSE LOCK JOINT OF THE BELL AND SPIGOT TYPE

JOINTS

Lead joints have been employed with excellent results in pipe lines of small diameters conveying water under fairly high pressures. The bell and spigot type of joint has been used under a variety of modified forms for connecting lap-welded pipes, but only two have survived the test of many years of experience. These are the Converse and the Matheson joints.

The Converse lock-joint, or coupling, Fig. 1, consists of a heavy cast-iron hub, with internal recesses at each head, which receive two lugs or rivets fastened to each end of each length of pipe. After the pipe enters the hub it is revolved slightly until the joint is "locked." In this position it is impossible to pull the pipe out of the hub without first shearing off the rivets. The annular space between the pipe and the hub is then poured with lead and calked in the usual way.

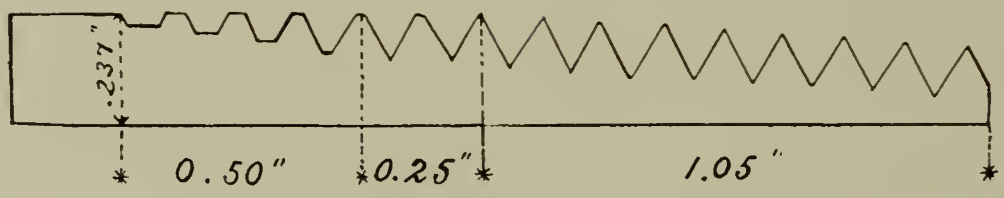


FIG. 2.—THE THREADED END OF A 4-INCH STANDARD PIPE

The Matheson joint is formed by expanding one end of each length of pipe sufficiently to form a bell or socket, which is reinforced at the extreme end by shrinking on a steel band. A groove is cut around the outside of the spigot end, to resist the tendency of the lead packing to slip when the joint is under pressure.

Of the two forms of lead joint described, the Converse is much the stronger, and therefore better adapted to high pressures. When reasonable care and skill are used in laying Converse pipe, the joints can be relied upon to stand much higher pressures than are commonly considered safe for lead joints. In the summer of 1901 a pipe line was laid by the Pacific Improvement Company near Santa Barbara, consisting of 10,000 feet 7-inch No. 9 gauge, 10,000 feet 8-inch No. 8 gauge and 13,500 feet 8-inch No. 6 gauge, all Converse joint steel pipe. This line terminates in two branch lines, each leading to a reservoir. At the end of each branch is a gate valve. As the total head is 1370 feet, it was not intended that both gates should ever be closed at the same time. However, after the line had been in operation for some time, an employee carelessly closed one of the gates without first opening the other, with the result that the entire line was subjected to a static pressure that amounted at the lower end to 590 pounds per square inch. A careful inspection of the line soon after failed to disclose a single leak. Another example, the 8-inch force main of the Prescott (Arizona) Waterworks, where several miles of Converse steel pipe 0.14 inch thick are being operated under a maximum working pressure of 420 pounds per square inch, is a forcible illustration of the efficiency of a properly designed and well-made lead joint, even for high pressures.

These examples have been cited to show that although lead joints for high pressures are not generally regarded with favour by hydraulic engineers, they are nevertheless worthy of some consideration. They have the merit of being economical in first cost and of being easily and readily repaired in case of leakage. Generally speaking, however, the working limit for lead joints should not exceed 300 pounds pressure per square inch.

Screw joints are formed by means of sockets or couplings, into which

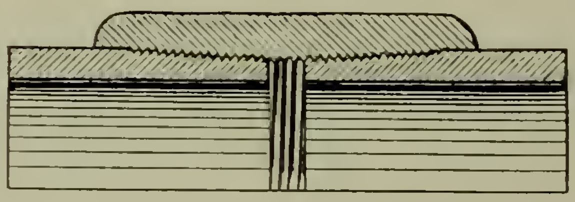


FIG. 3.—A LINE PIPE COUPLING

are screwed the threaded ends of the pipes. Couplings for standard pipe have straight threads, while the pipe threads have a taper of $\frac{3}{4}$ inch to 1 foot. After screwing together a number of standard pipes, it will be found that at nearly every joint a portion of each pipe thread remains exposed outside the socket. These are the weak portions of the pipe, and there is always danger of breakage at the bottom of an exposed thread from bending stresses which cannot always be avoided in laying a line of pipe. This danger, however, is minimized by the practice of cutting vanishing threads on the pipe. Fig. 2 shows a section through the threaded end of a 4-inch standard pipe. The threads have a pitch of $\frac{1}{8}$ inch (8 threads per inch), and their total length is 1 8-10 inches. Starting at the end of the pipe there are eight perfect V-threads, then two threads that are perfect at the bottom and slightly flattened on top, and finally four imperfect threads, the last one being but little more than a scratch.

The line pipe coupling (Fig. 3) is a

modified form of the standard pipe coupling, from which it differs in the following important details:—

1. It is longer and heavier.

2. The ends are recessed, in order that they may fit the pipe snugly just outside the thread, which is thereby fully protected from any bending stresses that may come upon the pipe.

3. The threads have a taper of $\frac{3}{4}$ inch to 1 foot, to correspond to the taper of the thread of the pipe. This insures a perfect contact for every thread—a prime essential for tight joints.

A leaky line pipe joint indicates imperfect or damaged threads or carelessness in connecting the pipes. To avoid damage from transportation, it is the practice of the best mills to screw a heavy guard or protector (usually a half coupling) on the exposed thread of each length of pipe.

In California, line pipe is largely used to convey oil under pressure. A considerable number of 2-inch, 3-inch and 4-inch lines are in operation in the several oil fields of the State, and some of them are subjected to very high working pressures. The Standard Oil Company's 8-inch line will be referred to later.

Line pipe is also used in California for the transmission of gas under high pressures. In many localities it is more economical to supply two or more towns from one source, through small pipes at high pressures, than to construct and operate a generating plant in each town.

In one of the first attempts at high-pressure gas transmission in California 2-inch standard pipe was used, but after the completion of the line the joints leaked so badly at a pressure of 15 pounds per square inch that it became necessary to take up the pipe and relay it after replacing the couplings with line pipe couplings. In contrast with this unfortunate experience may be mentioned another similar undertaking—a 9-mile line, consisting of 2 inch and $2\frac{1}{2}$-inch line pipe. The line was tested at frequent intervals during the progress of the work, and in one instance, when a leaky joint was detected, all the pipes were taken up and relaid as far back as the leak. Upon the completion of the first 5 miles of the line it was tested to 100 pounds air pressure, for a period of 36 hours, without developing the slightest leak. These two examples show the superiority of line pipe couplings and the advisability of using them in preference to standard couplings for high pressures.

FIG. 4.—EXPANDED JOINT WITH TWO ROWS OF RIVETS

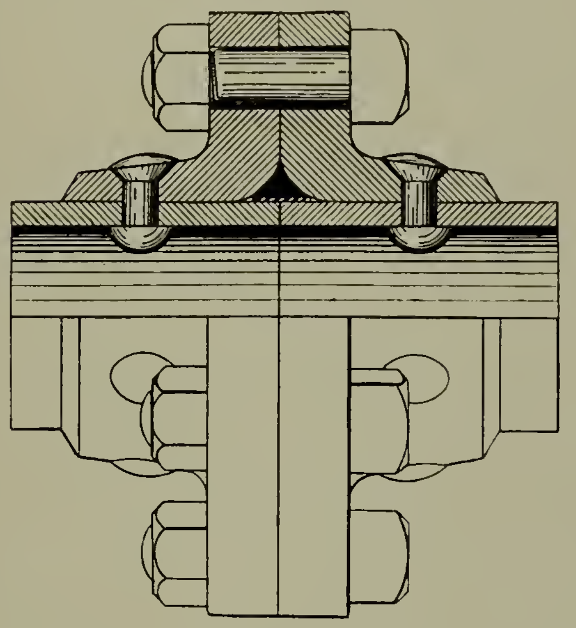


FIG. 5.—RIVETED FLANGES BOLTED TOGETHER WITH A GASKET BETWEEN THEM

Riveted joints are frequently used in pipe lines whose diameters are not less than 20 inches, inside measurement, this being the smallest pipe in which even an undersized riveting helper can work to advantage. The maximum head for which this type of joint should be used is about 1200 feet, although it has been used for even higher heads. In laying riveted pipe, the lengths are riveted together after the manner of connecting the short sections in the shop, each length having a large and a small end. Field riveting and calking are sometimes done by hand and sometimes by compressed air. Riveted joints are also used for lap-welded pipes. They are then termed "bump" or "expanded" joints, because one end of each pipe is upset or expanded. The expanded end is beveled for calking. Ordinarily the joints are single riveted, but when very high heads are used, requiring heavy pipe, it has been found necessary to resort to double riveting in order to make the joints tight. (Fig. 4.)

Flange joints are more expensive than the preceding types, hence their use in hydraulic work is generally confined to extraordinary pressures. The flanges are usually faced in a lathe, but this alone will not prevent leakage. The faces may be ground together until they fit so perfectly that the joint will be tight, but this operation is very costly; hence the well-known expedient of using a filler or gasket of some pliable material—usually copper for steam pressure and rubber for hydraulic pressure. In a properly designed flange joint a small gasket may be made quite as effective as a large one, and there is no reason why it should extend outside the bolt circle.

With reference to the manner in which they are attached to the pipes, flanges may be classified as screwed, riveted and welded.

Screwed flanges of cast iron or cast steel, although largely used for steam, are rarely used for extreme hydraulic pressures, except for pipes of very small diameter. It is the practice of the Crane Company, of Chicago, in their steam-fitting business, to screw the pipe into the flanges until the ends project about 1-16 inch. By means of a special lathe the projecting ends are then cut off and a light cut taken off the face of each flange to make it normal to the axis of the pipe. To prevent leakage the threads of the flanges and of the pipe should have the same taper.

Riveted flanges (flanges riveted to the pipe) may be of cast iron, cast steel or pressed steel. They may be faced and bolted together with a gasket between (Fig. 5), or they may be riveted together as in Fig. 6, in which case they are made of pressed steel, without facing or gasket, the joints being made tight by calking the beveled edges of the flanges. It is an excellent practice to shrink the flanges on the pipe before riveting them.

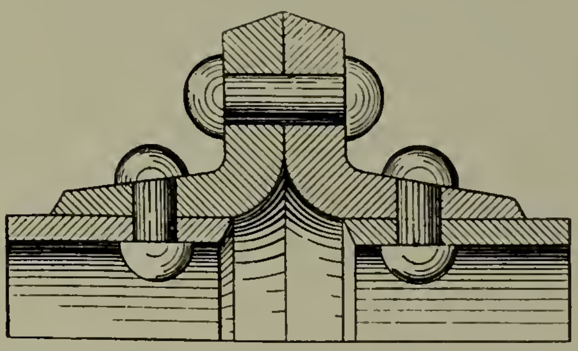


FIG. 6.—RIVETED FLANGES RIVETED TOGETHER WITHOUT THE USE OF A GASKET

Welded flanges of forged steel form an ideal joint for high pressures. The method of welding employed by the National Tube Company consists of slipping a rough-forged steel flange over the end of the pipe, then heating both pipe and flange to the welding point, after which they are withdrawn from the forge, the flange placed on an anvil and slowly revolved, while the rapid blows of a steam hammer directed against the inside of the pipe solidly weld flange and pipe together.

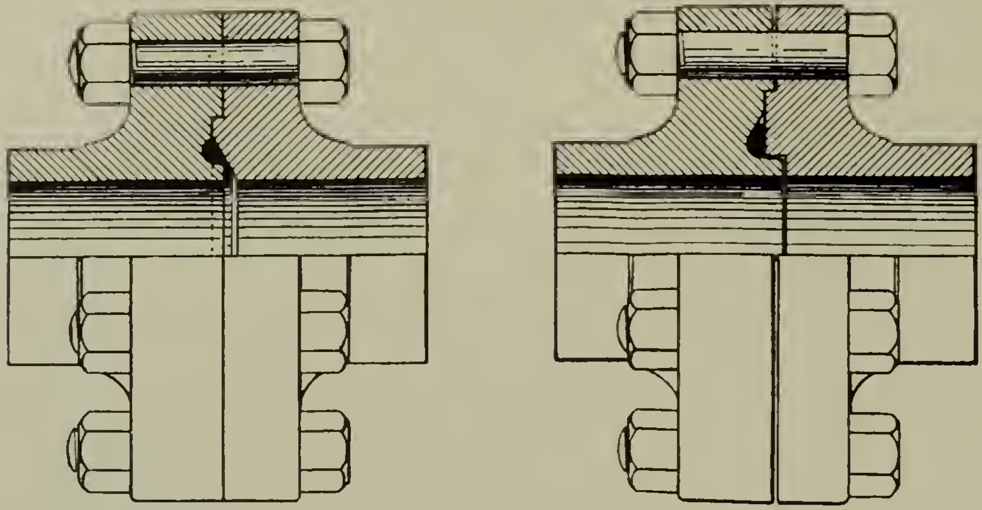
In Europe the welding is performed

by means of the electric arc. The flange is first beveled on its inside edge, so that when it is fitted on the end of the pipe a V-shaped space is left, into which small pieces of steel are laid. These, together with the contiguous metal of both pipe and flange, are heated to a welding temperature by the electric arc, the welding being performed by a pneumatic hammer. This operation welds the flange only about three-fourths through its thickness. The remaining fourth at the extreme end of the V-shaped filling is then burnt out next to the pipe by means of the electric arc, and filled, heated and welded in the same manner as the back of the flange.

The writer is informed that the Union Iron Works, of San Francisco, have a plant for welding flanges to steam pipes, but is not advised concerning the method employed.

As the solid welded flange joint is used for extremely high pressures, it is very important that the annular groove or recess in the face of one of each pair of flanges be so designed that when the flanges are bolted together the gasket cannot be forced out of its position in the groove by the pressure inside the pipe. The joint designed by W. R. Eckart for the Standard Electric Company (Fig. 7) and the one designed by the National Tube Company (Fig. 8) are both in use in important pipe lines in California, and are giving excellent satisfaction. The distinctive feature of these joints is the annular groove, into which is compressed a circular rubber gasket when the flanges are drawn together. No matter how great the pressure, the gasket cannot be blown out, since the tendency is to squeeze it more tightly into the groove.

A modified form of the welded flange consists of a heavy band or ring, welded on the outside of the pipe at each end, faced and grooved in the same manner as the flanges just described. The faces are drawn together by means of bolts through a pair of loose flanges behind the rings. (Fig. 9.) This style of joint was adopted for the 5-inch pipe line in the Simplon tunnel, Switzerland, operating under a maximum pressure of 2250 pounds per square inch. A similar joint is used in a power line near Vouvry, Switzerland, under a head of 3117 feet.



FIGS. 7 AND 8.—SOLID WELDED FLANGE JOINTS HAVING AN ANNULAR GROOVE INTO WHICH IS COMPRESSED A CIRCULAR RUBBER GASKET

A FEW REPRESENTATIVE PIPE LINES ON THE PACIFIC COAST

The following brief description of a few representative pipe lines is designed to illustrate the conditions under which hydraulic engineers have deemed it expedient to use the several types of pipes and joints referred to in this paper.

The San Joaquin Electric Company's pipe line (near Fresno) has the distinction of being the pioneer high-pressure power line of the Pacific Coast. It was constructed in 1896. Its length is 4020 feet and its total head is 1406 feet. There are 960 feet 24-inch riveted pipe No. 12 gauge steel, 860 feet 24-inch riveted ¼-inch steel, 400 feet 20-inch lap-welded 5-16-inch steel with Converse joints, 800 feet 20-inch lap-welded 5-16-inch steel with flange joints, and 1000 feet 20-inch lap-welded ⅜-inch steel with flange joints. The flanges were shrunk on and riveted to the pipes, one of each pair being recessed, while the other has a corresponding annular projection. Each joint contains 16 bolts 1 inch in diameter. A rubber gasket was used between the faces.

During the year 1900 the Standard Electric Company constructed two parallel pipe lines for power development, each consisting of 2813 feet 48-inch wooden stave pipe, 464 feet 48-inch riveted pipe 5-16-inch steel, 760 feet 30-inch cast-iron pipe with shells 1 inch, 1¼ inches and 1½ inches thick, corresponding to 275 feet, 550 feet and 700 feet static heads, respectively, and 2365 feet 30-inch lap-welded steel pipe with shells 7-16 inch, ½ inch, ⅝ inch and ¾ inch thick, depending upon the static head. The total head is 1475 feet. The joints for all of the lap-welded pipe are of the solid welded flange type. (Fig. 7.) The flanges are 2¼ inches thick. Each joint contains 32 bolts, 1 inch, 1⅛ inches and 1¼ inches, the size depending on the pressure.

The Keswick pipe line of the Northern California Power Company, constructed in 1901, is 6800 feet long, and has a maximum head of 1204 feet. It consists of 800 feet 42-inch wooden stave pipe, 3600 feet 30-inch riveted No. 8 gauge to ⅜-inch steel, and 2400 feet 30-inch lap-welded 7-16-inch to ⅝-inch steel. The lap-welded pipe has expanded joints, with one row of rivets for the 7-16 inch and ½-inch steel and two rows for the ⅝ inch.

The Colgate plant of the California Gas & Electric Corporation has five lines of 30-inch pipe, each of which is 1625 feet long, the maximum head being 702 feet. The upper portion (680 feet) consists of riveted pipe, No. 12, No. 10 and No. 8 gauge steel, while the lower portion (945 feet) consists of cast-iron, with shells varying in thickness from 1 inch to 1½ inches. The cast-iron pipes are 12 feet long, the joints being of the usual bell and spigot type, filled with lead and calked in the usual way. The pipes are firmly anchored to bed rock by massive concrete piers.

The De Sabla plant of the California Gas & Electric Corporation, near the town of Chico, contains two parallel lines of 30-inch pipe (the first completed last year and the second now in process of construction), each 6225 feet long, consisting of 5200 feet of riveted No. 10 gauge to 9-16-inch steel (maximum head approximately 1100 feet), 465 feet lap-welded ½-inch, 9-16 inch and ⅝-inch steel with expanded joints (maximum head about 1300 feet), and 560 feet lap-welded 11-16 inch and ¾-inch steel

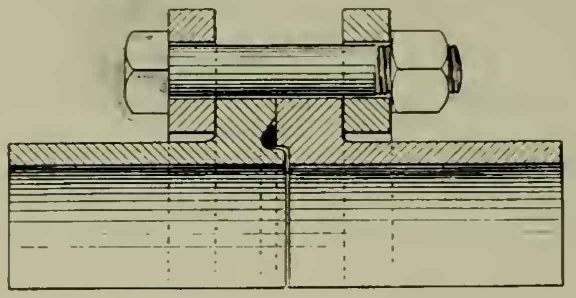


FIG. 9.—A FLANGE JOINT IN WHICH A HEAVY RING IS WELDED ON THE OUTSIDE OF THE PIPE AT EACH END AND THE RINGS BOLTED TOGETHER

with solid welded flange joints. The total head is about 1500 feet.

The pipe line of the Mill Creek No. 3 plant of the Edison Electric Company, near the town of Redlands, is 8400 feet long from the forebay to the power house. There are 2485 feet 26-inch and 2150 feet 24-inch riveted steel No. 14 to No. 0000 gauge, 2830 feet 24-inch lap-welded $\frac{3}{8}$-inch to $\frac{3}{4}$-inch steel with expapnded joints, and 620 feet 24-inch lap-welded $\frac{3}{4}$-inch steel with solid welded flange joints. (Fig. 8.) Near the power house the line divides into two 18-inch lap-welded $\frac{5}{8}$-inch steel branches, and each of these into two 14-inch lap-welded $\frac{1}{2}$-inch steel branches, all with solid welded flange joints. The total head is 1960 feet. The steel for the lap-welded pipe is basic open hearth, ultimate tensile strength 50,000 to 60,000 pounds per square inch, and the pipes were tested at the mill to $1\frac{1}{2}$ times the static pressures indicated by the profile.

The Standard Oil Company's pipe line, extending from the Bakersfield and Coalinga oil fields to Point Richmond on San Francisco Bay, a distance of 278 miles, was completed in 1903, and is used as a pumping main for the transportation of oil. It consists of 8-inch standard line pipe of soft open-hearth steel, ultimate tensile strength from 40,000 to 50,000 pounds per square inch. Each pipe was subjected at the mill to a hydrostatic test of 1500 pounds per square inch. The working pressure is approximately 600 lbs. per square inch.

The Columbia Improvement Company have recently completed near Tacoma, Wash., four lines of riveted steel pipe, each 1700 feet in length, and with a total head of 900 feet. Each line is made up of 450 feet 48-inch lap-riveted $\frac{1}{4}$-inch and 5-16-inch steel, 200 feet 45-inch butt-strapped $\frac{3}{8}$-inch steel, 400 feet 42-inch butt-strapped $\frac{1}{2}$-inch steel, 400 feet 40-inch butt-strapped $\frac{5}{8}$-inch steel, and 250 feet 36-inch butt-strapped $\frac{3}{4}$-inch steel.

Although the foregoing brief description is far from being complete, it will serve to give a general idea of high-pressure practice on the Pacific Coast, which has been one of the objects of this paper.

The writer is indebted to T. W. Brooks, of the National Tube Company, for illustrations of high-pressure joints, and to G. R. Field, of the Risdon Iron Works, for information concerning the pipe lines of the Columbia Improvement Company.

During 1905 the price of copper rose from $14\frac{1}{2}$ to 19 cents, the average being $15\frac{1}{2}$ cents per pound.

Single-Phase Traction in Hamburg

THE City Council of Hamburg, according to "The Electrical Engineer," of London, have decided to build five electric lines, part of which will be of underground and the other part of elevated construction. The heaviest grades are not to exceed $2\frac{1}{2}$ per cent., and the curves are not to be sharper than 328 feet in radius. There will be fifty cars, each supplied with three 120-H. P., 750-volt, 25-cycle, single-phase motors. The trolley wire will be supplied with current at 6600 volts, a car transformer being used to reduce the voltage for the motors. the latter are four-pole machines running at a normal speed of 600 revolutions per minute. Each motor weighs 5940 pounds alone, or 6600 pounds complete with gear.

The main car transformer weighs about 2200 pounds, and the regulating transformers about 440 pounds. The total weight of the electrical equipment will be about 16.5 tons per car, while the total weight of the double cars used will be, including the average load of 40 to 45 passengers, about 75 tons. The total seating capacity of each double car is 140 persons.

Current will be taken through two trolleys of the bow type. The overhead line will be of the catenary construction, using a grooved conductor of 80 square millimetres (.124 square inches) cross-section and a single steel suspension wire 6 millimetres (about $\frac{1}{4}$ inch) in diameter. The conductor will be supported from the catenary at intervals of about 11 feet 5 inches. The height of the conductor above the rail will be 18 feet, normally, and $15\frac{3}{4}$ feet under bridges.

Each train will be made up of two or three double cars controlled by a multiple unit system. The circuits to the motors are opened between adjacent running points. The total cost of building and equipping the lines is estimated at $10,285,900. Two lines are to be built within five years, and the remaining three within the following five years. It is proposed to lease the system to a company for a period of forty years, the municipality receiving a definite percentage of the gross earnings and later a portion of the net profits.

Power Costs

THE comparative costs of fuel per horse-power year for steam and gas engines under various conditions of operation and cost per unit of fuel are given in the following table, compiled by the Automatic Gas Producer Co., of New York.

STEAM ENGINE AND BOILER

	Cost per H. P.-Year.					
Coal per H. P.-Hour—Coal at—	3 Lbs.	4 Lbs.	5 Lbs.	6 Lbs.	7 Lbs.	8 Lbs.
$2.00 a ton	$9.00	$12.00	$15.00	$18.00	$21.00	$24.00
2.50 "	11.25	15.00	18.75	22.50	26.25	30.00
3.00 "	13.50	18.00	22.50	27.00	31.50	36.00
3.50 "	15.75	21.00	24.75	31.50	37.00	42.00
4.00 "	18.00	24.00	30.00	36.00	42.00	48.00
4.50 "	20.25	27.00	33.75	40.50	47.25	54.00
5.00 "	22.50	30.00	37.50	45.00	52.50	60.00

GAS ENGINE

Using 20 cubic feet of illuminating gas per H. P.-hour:—						
Cost per 1000 cubic feet	$0.75	$0.80	$0.85	$0.90	$0.95	$1.00
Cost per H. P.-year	45.00	48.00	51.00	54.00	57.00	60.00
Using 15 cubic feet of natural gas per H. P.-hour:—						
Cost per 1000 cubic feet	$0.16	$0.18	$0.20	$0.22	$0.24	$0.25
Cost per H. P.-year	7.20	8.10	9.00	9.90	10.80	11.25

Using producer gas, $1\frac{3}{4}$ pounds of coal per H. P.-hour:—							
Cost of coal per ton	$2.00	$2.50	$3.00	$3.50	$4.00	$4.50	$5.00
Cost per H. P.-year	3.34	4.17	5.00	5.83	6.67	7.50	8.33

GASOLINE ENGINE

Using one pint of gasoline per H. P.-hour:—							
Cost per gallon	$0.08	$0.09	$0.10	$0.11	$0.12	$0.13	$0.15
Cost per H. P.-year	30.00	33.75	37.50	41.25	45.00	48.75	56.25

The figures are based on ten working hours per day and 300 working days per year, and the range of prices and consumption rates are such as to enable one to make very satisfactory comparisons.

A practical comparison of the value of elevators and escalators for handling large crowds in department stores, was made by keeping a careful count of the number of people carried by escalator and elevators, respectively, in Macy's department store, New York City, and the "Boston Store," in Chicago, during the recent holiday season. During the month of December, up to and including December 24, the escalator at Macy's took, on an average, more people away from the first floor than all of the elevators in the entire building, and it has always carried more than the eight elevators nearby.

An application was recently made to the New York Rapid Transit Commission by the Behr Monorail Co. for a route for a monorail line from the subway terminal in Brooklyn, at Atlantic and Flatbush avenues, to Coney Island. The cars of this system are in the shape of an inverted V, and run on a single raised track.

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Leading Articles

Increasing the Sale of Current-Consuming Devices

THE proposed formation of the Co-operative Electrical Development Association, noted recently in these pages, is the initial step in a movement by the manufacturers of lamps and other allied interests, together with central station men, to increase the sale of devices using electric current in their operation.

To briefly review the facts already given, it may be said that the idea was first brought out in a report of the advertising committee of the Licensed Manufacturers of Incandescent Lamps. A suggestion was made that co-operation among themselves, with other electrical manufacturers, and with central stations, would result in large benefits to all. Co-operation in educating the public to increased use of electric devices was a common ground on which all could stand.

An appropriation was made to carry on the work, but as the plans were further developed, the comprehensiveness of the scheme became apparent, and it was decided to form a separate organization under the name of the Co-operative Electrical Development Association. This it is now proposed to do under the laws of New York, which provide for the formation of a corporation having members without capital stock, and not paying dividends.

Assesments of one-fifth of one per cent. of the gross business done by each member of the association, are to provide the funds to carry on the work. Twenty-seven directors will be elected, the members being divided into classes and voting in proportion to their assesments. Officers will consist of a president, two vice-presidents, a secretary, a treasurer and a general manager, the last named being in active control.

The lines on which the work is to be done are certainly extensive ones. Literature will be issued periodically containing suggestions, which it is hoped will stimulate central station managers to more aggressive business-getting methods. A quarterly publication in magazine form will tell of how the most progressive stations are extending their service. Applications of electricity will be classified; for instance, under "Drug Stores," every possible use of electric current for light, heat and power for this kind of service will be listed.

A newspaper bulletin issued quarterly will contain reproductions of the best newspaper advertisements of central stations. An editorial section will give central station managers and others opportunity to tell of their methods of increasing business. Another section will be for bright, newsy paragraphs, acceptable for the reading columns of local papers. Besides the quarterlies, booklets on special topics are to be sent out.

The use of special representatives, to present the question of business-getting in papers before the various electrical societies, and to interest architects, builders, real estate men and others in the desirability of wiring old and new buildings, is also a part of the general plan. Prizes of $500, $300 and $200 have already been offered for papers on the organization and conduct of a new business for central stations. The details of this offer are given in the advertising pages of this issue.

From this summary of the object and plans of the association, it will be seen that an aggressive movement is under way. And it is a timely one. Already, the gas industry has formed the National Commercial Gas Association to find ways and means for more actively exploiting the sale of gas. Its activity is shown in a recent ninety-day test of newspapers, showing that the number of advertisements of gas appliances were twice those of electrical ones, although electric light companies are to gas companies as three to one. In street cars, magazines and other periodicals, the gas advertisements greatly outnumber those of electrical appliances.

One of the great reasons for the necessity of aggressive work in the extension of electrical service is that the increased cost over gas can be offset only by showing the consumer the added advantages of electricity.

Another great handicap is that gas was first in the field. Many residences are fitted up for gas only, and the inconvenience and cost of having walls torn open for the installation of wiring, constitutes a difficulty almost impossible to overcome. In new houses, however, and in those undergoing repairs, it should be a comparatively easy matter to induce the architect or owner to install electric wiring alone or in combination with gas pipes.

Once the added convenience of electrical devices is realized, there will be little use for gas. But the public can be made to see this only through a proper amount of advertising and aggressive personal solicitation. The manufacturers also must co-operate in putting out apparatus of reasonable cost and length of life. They must supplement the advertising of central stations, and send out attractive booklets for general distribution.

The complaint has been made that the National and State electric light associations deal too much with technical and operative subjects at their conventions, to the exclusion of methods of business getting. There is no doubt that an increased service is of equal importance with increased operating efficiency, as both add to the profit and result in increased dividends. The central station will profit by increased service, the manufacturers by increased sales, the contractors by increase in number of installations, and the salesman, jobber, dealer and all other allied interests by the added activity in their respective lines.

Municipal Pumping from Central Stations

THE extension of central station business involves the investigation of many local industries in the search for prospective customers, and great progress has been made in the introduction of electric power into all kinds of mercantile and manufacturing pursuits.

A field which has thus far been comparatively little exploited, however, is that of municipal pumping. In a few instances, notable installations of electric pumps in connection with waterworks have been made, and the advantages of electric over steam power for this kind of service are so great that every central station manager ought to assure himself whether or not opportunities for selling current to his municipality exist in connection with the water supply.

Of course, many towns are so situated that their water supply does not need to be pumped, and many others are to-day operating very economical steam plants. In growing communities, however, the present supply is often perilously near the point where it is unable to meet the demands of the increasing population without heavy expenses for new plants and reservoirs. For this reason, it is decidedly worth while for the central station man to find out if he cannot be useful in helping to solve the problem without the large increase in investment and operating cost which the establishment of a new steam-driven pumping station entails.

The great advantage of such a load lies in the facts that it is practically constant throughout the operating period, and that the pumping plant may be shut down wholly or in part during the hours of the station peak loads. This may be done without any injury to the water supply of the community, provided a reasonable amount of reservoir capacity is available. During the other hours, probably 85 or 90 per cent. of the day, the central station is sure of a steady customer. For this reason, a flat rate, based on the maximum amount of power used in the plant, can often be made to the mutual advantage of the city and the electric light and power company. It is well to remember that the steady power consumption of such an installation may easily be a more profitable load than the more fitful demands of a motor load of much larger rating, but of smaller load factor.

The advantages of an electric pumping plant are found in a lower first cost per horse-power installed, than usually obtains with a steam-driven installation, a lower cost of attendance, smaller consumption of oil and waste, and a cleaner and more compact installation as a whole. It is often necessary to install a pumping plant in a residential section where the hauling of coal and ashes, and the smoky chimney of a steam plant are likely to be regarded as unmitigated nuisances with latent possibilities in the way of damage suits. In such cases, the electrically driven plant is quite sure to be much more favourably regarded by the community, and often the good will of the immediate neighbourhood can be permanently assured by supplying the streets nearest the plant with a little extra illumination.

The chief disadvantage of an electrically driven pumping plant, with geared pumps and motors, lies in the noise made by the gearing. It is a difficult matter to transmit 400 or 500 H. P. through gears without a considerable amount of noise, but the use of rawhide pinions running in oil, or the chain or belt drive, is worth considering in cases where direct connection cannot be had.

With centrifugal pumps, the motors may be direct-connected and wound for comparatively high speeds, but with reciprocating pumps it is almost out of the question to avoid gearing or its equivalent. For example, an induction motor cannot be built at moderate cost to operate much below 150 revolutions per minute on 60-cycle current. The 400-H. P. machines used in pumping work at Montreal are necessarily built as very large units, in order to drive by single-reduction gearing 5,000,000-Imperial-gallon pumps at a piston speed of 115 feet a minute.

The reliability and the refinement of design of these large induction motors are evident from the fact that the rotors weigh 25,000 pounds, and revolve at a peripheral speed of 6500 feet a minute with only a 1-16-inch air gap, the rotor diameter being 13 feet. The problem is much more easily solved with 25 or 40-cycle current. Perhaps the most notable example of a centrifugal pumping plant, electrically driven, is that of the Schenectady waterworks, where two 800-H. P. induction motors are each direct-coupled to a two-stage vertical 18-inch pump, having a capacity of 12,000,000 gallons a day.

For municipal pumping, either an alternating-current or a direct-current motor can be successfully employed, but the factors of simplicity and freedom from trouble lie on the side of the former type. The synchronous motor is more efficient than the induction type, but it is complicated by the necessity of exciting it by direct current and of providing means for bringing it up to synchronism. If the line voltage drops suddenly and sharply, the machine may go out of step and the whole plant have to be shut down and started up again before pumping can proceed.

The induction motor will stand almost any kind of abuse except deliberate injury; its power factor in large sizes at full load should be well up towards 90 or 95 per cent.; it is easily started by reactance coils in the stator circuit, and is generally more reliable than its rival. In damp localities, it is incomparably superior to any machine with a commutator, and it requires merely nominal attention.

On the score of efficiency, the electric pumping plant ought to show a marked economy over the steam

driven installation, with anything like reasonable power rates; the personal peculiarities of the attendants have little bearing upon the production, and it is to be hoped that as time goes on many installations of this character will be placed in service, to the mutual benefit of the water consumer and the central station.

Hard-Drawn Copper Wire

THE drawing of copper wire is described by T. B. Doolittle in a recent issue of "The Harvard Engineering Magazine." The copper is received from the smelting works in the form of bars, which are approximately 54 inches long, with an average diameter of about 3¾ inches, and weigh about 200 pounds each.

The first operation is to put the bars into what is termed a "continuous furnace," the bars going in at one end of the furnace and out at the other. In their passage through they are heated to about 1742 degrees F., at the rate of about two bars a minute.

The heated bars are then put through a series of grooved rolls. Each succeeding groove being smaller, a reduction of the 3¾-inch bar to a cylinder with a diameter of 5-16 inch results. These are now called rods, and are taken up on a reel in the form of a coil about 30 inches in diameter. These coils are then taken from the hot-rolling department and are cold at that time. They are then plunged into a bath of sulphuric acid and water for the purpose of removing whatever oxide has been formed in the hot-rolling operation. After about 20 minutes in this solution the oxide is removed and the rods are then taken and thoroughly washed with clean water, after which they are immersed in a vat containing a lubricant of tallow and soap. The rods are now ready for the drawing process.

The rods are substantially drawn on what is termed by wire manufacturers a "continuous wire-drawing machine," that is to say, the 5-16-inch rod goes in at one end of the machine, and, after passing through several dies, each one reducing the diameter and hardening the wire, it finally is drawn around a block to the finished size, say, 0.104 inch.

In making this reduction, the copper is reduced in diameter from No. 1 wire gauge to No. 12 wire gauge, or, in technical terms, the wire is "eleven numbers hard." This process gives the wire the greatest amount of tensile strength possible from commercial copper and yet preserves its elasticity. The cost of production is enormously reduced by this new process, whereas, under the old process, a very skilled workman was required for each single drawing, an attendant is now able to care for several continuous drawing machines that are run at a speed unapproachable by the old method. In the smaller sizes of wire, diamond dies are employed which, in themselves, represent a very considerable investment.

Commercial copper in its soft state has a tensile strength of about 28,000 pounds per square inch, with an elongation of about 36 per cent., and by the cold-drawing process above described, the tensile strength is increased by each number drawn, and the elongation is reduced; therefore, when the copper wire is drawn eleven numbers hard, it has a tensile strength of about 64,600 pounds per square inch, with an elongation of about 1 per cent. The wire is then taken from the wire-drawing blocks, so-called, and is carefully inspected for tensile strength, elongation, torsion and conductivity. The inspected wire is then carefully packed by wrapping each coil with burlap, so that it does not become bruised or damaged in any way by transportation.

Electrically Driven Centrifugal Pumps for High-Pressure Fire Service in New York City

AS a result of a recent ordinance authorizing the building of two new fresh and salt water pumping stations for the borough of Manhattan, bids were closed and contracts awarded a short time ago to the Allis-Chalmers Co., of Milwaukee, Wis., by the Commission of Water Supply, Gas and Electricity.

The equipment to be furnished consists of ten multi-stage, electrically driven centrifugal pumps, identical in design to those built by the Escher, Wyss Co., of Zurich, Switzerland, the rights of which for this country are owned by the Allis-Chalmers Co. The equipment will be installed in two stations now in course of construction, and identical in every way even to the arrangement of the interiors. The plants will be laid out to accommodate eight pumping units, the piping being so arranged that when the three future pumps are installed it will be necessary only to remove the blank flanges from the T's to make the present arrangement of piping suitable for the operation of eight pumping units.

The pumps will be of the horizontal shaft, multi-stage, centrifugal type, connected to 800-H. P. induction motors. Each pump will be constructed with six runners, that is, the water will be handled in six stages, each stage raising the total required amount of water through one-sixth of the total required head. The pumps are designed to give their maximum efficiency when delivering 3000 gallons of sea water each per minute, at a speed of approximately 735 revolutions per minute and delivering against a discharge pressure of 300 pounds per square inch.

The induction motors are of Allis-Chalmers make, built in accordance with the specifications of the Department of Water Supply, Gas and Electricity. It is expected that these stations will be in operation by the first of October.

Annual Convention of the National Electric Light Association

THE annual convention of the National Electric Light Association will be held at Atlantic City on June 5, 6, 7 and 8. The meeting hall will be in the small auditorium of Young's Pier, and the large exhibition room on the front of the pier has been secured for the exhibits of the associate members.

The present programme is to open the exhibition hall on Monday evening, to hold a reception and ball in the new "Blenheim" on Tuesday evening, and a banquet, at which will be present the governor of the State and many other notables, on Thursday evening.

The entertainment of the members will be confined to other than meeting hours, as it is intended that this shall be a working convention. A feature of the banquet will be the cooking of the menu by electric current. This is now being arranged, and it is expected that all the prominent manufacturers of electrical heating devices will take part.

The attendance during the last two conventions has been about 1300, and it is expected that at Atlantic City the number will be increased to not less than 2000.

The Buffalo Subway Railroad Company has been incorporated with a capital of $1,000,000. It is the intention of the company to build a subway similar to the one in New York City.

The municipal authorities of Berlin, acting with those of eight suburban towns, have decided to take over the properties of the Berlin Street Railway Company.

American Institute of Electrical Engineers

Telephone Engineering Discussed by J. J. Carty, Chief Engineer of the New York Telephone Company

AT the February meeting of the American Institute of Electrical Engineers, a paper on "Telephone Engineering" was read by J. J. Carty, chief engineer of the New York Telephone Co. After briefly discussing the various engineering professions, the author said that inasmuch as the telephone is an electrical instrument, and inasmuch as electrical phenomena exert a dominating influence in the telephone art, telephone engineering is classed as a branch of electrical engineering, although it comprehends important elements not at all electrical in their character; indeed, it is a recognition of the existence of these elements and a knowledge of how to deal with them adequately, which constitute one of the important requirements of telephone engineering. A good knowledge of electrical laws and a fair acquaintance with electrical machinery may be gained in our electrical schools; and graduates from them are, as a rule, proficient in these matters. Telephone engineering comprehends not only these, but other factors, the existence of which is not generally recognized.

Not so many years ago it was thought that the functions of the telephone engineer consisted of doing little more than to provide and install switchboards. He was supposed to be consulted occasionally about the station apparatus, and later, when cables were introduced, his activities were extended so as to include the testing of cable after it had been bought and laid.

At that time telephone companies took almost an exclusively switchboard view of the telephone business. A building would be selected by someone connected with the company, and the engineer would be consulted principally as to the selection of the switchboard and the placing of it in position. The size and location of the building, its relation to the existing and probable future subscribers, and all of the vast number of other factors now considered so vital in determining such matters, received but scant consideration. So it was with cables; whether the cable should contain wires of No. 22, No. 19, or No. 16 gauge, whether the insulation should be of cotton, rubber, or gutta percha—these were questions which were as likely to be settled by the purchasing agent as by the engineer.

To give a correct view of the true scope of telephone engineering, the author broadly discussed a typical problem in telephone management, illustrating the various points by reference to certain details which were considered in connection with the problem chosen.

Taking the case of New York City, with the suburban territory tributary to it, it was assumed that it was the intention of the telephone company to install within that territory a telephone system which would work at a proper degree of efficiency, and at the same time yield to the investor a fair return upon his investment, and that it was necessary not only that this condition should exist during the first stages of the project, but that the undertaking should be so managed that this condition would be maintained indefinitely. With such a problem before the telephone management, what part of it should the management require the telephone engineer to work out? This question was answered by describing in general terms, and sometimes, for the purposes of illustration, in considerable detail, what should be the work of the telephone engineer, in such a case.

The first question which the engineer must decide is, what is the period for which such construction as may be required should be planned? This requires for its answer that a vast amount of data should be collected, and that careful and long-continued study and investigation should be given to a large number of factors. These, among other things, involve first cost and character of construction of the diverse portions of a plant of such complicated nature, annual charges such as maintenance, depreciation and interest, and local conditions bearing upon the possibility of the renewal or extension at some future time of all the elements of the plant.

In addition to this, due regard must be paid to possible changes in the art, and also the fact that many cases arise where it is necessary to carry out at the beginning, especially in underground work, all of the construction which may ever be needed.

At the outset, the question of the period for which to plan depends upon the expectations of growth. With a given expectation of growth, the engineer, by taking into account all the factors of the case, and balancing the annual charges resulting from the initial investment against the cost of reconstruction and rearrangement of the plant at some future time, arrives at the economical period for which to plan.

In this work the predictions as to growth are of the first importance, and, inasmuch as accurate predictions of this kind are attended with the greatest difficulty, it is essential that not only the judgment of the engineer, but that of the business management and all others who might be able to advise in connection with the matter, should be obtained.

At this stage of the work it is of the utmost importance that the bearing of these estimates of growth upon the future of the plant should be thoroughly understood by the business management, whose functions, in the nature of the case, exercise such a profound effect upon the extent and character of such growth. It is the duty of the engineer to make this point clear and to obtain from the business management serious and responsible estimates of future growth.

The number of lines which may be expected having been agreed upon, the question of for how long a period ahead we should plan is determined by a number of circumstances. For such conditions as obtain at New York, the period for much of the construction has been found to be from seventeen to twenty years. This figure is arrived at by taking into account a large number of factors, such as life of the central office switchboard, which is placed at about fifteen years, the relative costs of placing in the subways a large number of ducts initially as compared with adding new ducts after a period of about twenty years, the uncertainty regarding the changes in the state of the art, and the difficulty of foretelling with sufficient detail con-

ditions which are expected to obtain during a period so far ahead as twenty years.

In the case chosen for illustration, which was New York, the economical period was found to be about twenty years, and it was attempted to plan for conditions which would obtain in the year 1920, and for each year up to that date. The total number of lines to be provided for in the island of Manhattan is 300,000. The working out of the general plans for providing for this number of lines, which it was expected would be reached by the year 1920, constitutes what is known as the "300,000 line study." To give an idea of the nature of part of the work of the telephone engineer, the author outlined in general terms the character of this study.

Having determined upon 300,000 lines as the proper foundation of the study, and having received the proper authorization from the business management to proceed on that basis, the next step is to plot on a map the probable distribution of these lines. This is done, not by giving the location of each line, but by indicating by blocks the most probable distribution. Here again the judgment of the engineer must be assisted and directed by the business management, for next in importance to determining the total number of lines to be provided for comes the question of their distribution.

The number and distribution of lines having been agreed upon, the next step is to determine the number and arrangement of central office districts, the size and boundaries of these districts, and the size and location of the central office switchboards.

It is conceivable, although obviously impracticable, that all the 300,000 lines might be extended to one central office and operated in switchboards there; it is only necessary to state such a proposition to exclude it from further consideration. On the other hand, it is conceivable that a central office might be established in each block; this also is absurd and needs no further consideration. Somewhere between these two extremes must lie the most economical size and number of central offices.

The next stage in the problem is to determine this number; to do this no formula, simple or otherwise, is available. The only practicable method is to lay out the territory to be served, in accordance with a number of different arrangements of districts and centres, starting in, say, with ten centres and extending the study up to as many as thirty or forty, or even more. In the case of all these arrangements, there would be certain elements of cost which would not be changed by the different arrangements of central offices assumed. Block wiring and station instruments are examples of these. These elements of cost are omitted from the comparison. All of the items of cost, however, which vary with the different number and arrangement of central offices are computed, all of these being reduced to annual charges.

From these figures, as applied to the various layouts, may be seen the number of central offices and the districts which are ideally most economical, so-called, for the reason that the practical application of such results requires that a difficult and very complicated adjustment of the existing plant, to conform as nearly as possible to the ideal condition, must be carried out.

Even the vast amount of labour shown in the brief statement of the steps of the study thus far, by no means represents all that must be done. Before there can be made a comparison of the relative economies of the various groups of offices, a series of studies within studies must be carried out upon many other important elements of the problem.

The first of these is the switchboard study. Before the switchboard study can be made, general methods of operating must be agreed upon, such as the method of handling toll business, whether it shall be done wholly upon a toll board or partly upon a toll board and partly direct from "A" positions, whether it shall be done wholly upon a "two-number" basis, or substantially upon a "particular party" basis. The best method of handling local business must be determined. It must be decided whether the business shall be upon call wires or otherwise; what shall be the capacity of the call wire; what shall be the load which will be assigned to the various operators in the system, this in turn being dependent, among other things, upon the character of the service which it is thought necessary to render.

Having agreed upon these and other fundamental data, the question of the best type of switchboard, whether it shall be full multiple or partial multiple, whether it shall be of the transfer type or otherwise, must be settled. The limit, so far as size is concerned, of the multiple board, or any other type which may be considered, must be determined. Also there must be settled a very large number of questions cropping out at every point involving maintenance and operating expenses and methods. All these factors having been duly weighed, the maximum size and type of switchboard is agreed upon.

The switchboard determinations having been made, the type of cable to be employed must be settled upon. Here again a series of studies is necessary. Of first importance in the cable study is the determination of the standard of transmission which is to be employed, not only for talk between offices within a zone such as Manhattan Island, but also the standard of transmission which it is necessary to maintain between Manhattan Island and the suburbs, and between various points in the suburbs passing through Manhattan, and to long-distance points. The importance of this determination will appear when we consider the standard already adopted as the Manhattan standard, which is, assuming the use of the present common battery apparatus, that the cable employed in Manhattan shall at all times be such that it will give in the worst case a talk as good as could be obtained between two central offices joined by a trunk cable of 10 miles of the standard type, having the No. 19 gauge conductors, with a mutual capacity of 0.07. If this standard were lowered so as to employ the use of No. 22 gauge cable instead of No. 19, it would permit the use of a trunk cable costing half as much as that required by the present standard, thus reducing the number of ducts required and in that way profoundly affecting the results of the study.

In considering the type of cable employed, not only must the standard of transmission be borne in mind, but in determining the various types of cable needed, a long series of special studies is required. These are conducted with a view to determining upon that form of construction giving the highest standard of transmission, preserving the best mechanical conditions needed for hauling in and out of the duct, and requiring a minimum of attention from the maintenance point of view. Where suburban and long-distance circuits are to be considered, the problem of loading cables also presents itself.

The general features of the study having been determined upon, and the time having arrived to erect a given central office at a centre previously located, the question of obtaining the necessary real estate and erecting the central office building presents itself. In such cases it is usually impossible to obtain the desired property exactly at the ideal centre. Practical real estate conditions must be met, and, of the various parcels of property offered, that is chosen which, taking

into account all of the circumstances of the case, results in the lowest annual charges.

The distance of a given site from the main subways, the character of the neighbouring buildings, the price at which the property can be obtained, the possibility of reconstructing the existing building which may be upon the property, or the necessity of removing it and erecting a new one, and other similar points—all these have to be carefully worked out before a report can be made to the management setting forth the most economical land to purchase. After these matters have been decided upon, the details of construction of the building must be further studied.

This outlines a telephone development study as it is more particularly concerned with the local plant, but as the local plant must be, as time goes on, more and more intimately connected with neighbouring plants in the suburbs, and with more distant plants reached by long-distance wires, most careful study must be given to the best methods of establishing proper relations with those plants.

Without attempting to outline in any detail the nature and extent of the work involved in the methods employed in making a suburban toll line study, and without going at all into the question of methods of establishing the service to long-distance points, the author said that, considering the broad features of these various classes of conditions, it has been found best, in the particular case taken for an example, to divide the telephone business into three classes:—local, suburban, and long distance.

In determining what shall constitute the local class, the engineer finds himself engaged in a problem of great magnitude, which primarily concerns the business management, and which is affected by important public and economic considerations as well as by engineering factors and methods. If the local zone is made too extensive it greatly increases the magnitude of the trunk-line plant from which no toll revenue can be derived. This fact reacts upon the rates in such a manner as to make it impossible to give as low a station rate as might otherwise be the case. This tends to restrict the growth of stations, and hence will act as a check upon the growth of the business at large.

The local zones having been determined upon, it must next be decided what shall be the limits of the suburban business, and what shall be classed as long-distance business. The various points necessary to be taken into account in determining these questions, involve not only those physical factors ordinarily considered to constitute engineering, but also those methods of calling which may be permissible on the part of the subscriber, the entire system of toll rates which may be adopted by the telephone company, the question of whether the subscribers' names and numbers should be listed or not, and other questions of this nature.

The author was not surprised that some who superficially consider the subject are inclined to doubt the value of results obtained by these methods. This feeling is strengthened when they consider the nature of some of the fundamental data upon which all of the work rests. For instance, unless there is made a fairly correct forecast of the probable growth of subscribers' lines for a period of fifteen or twenty years in advance, it is clear that substantial errors will be made; but more than this, it is necessary not only to forecast the total number of lines expected, but their location must be determined within close limits.

But this is by no means all. Not only must the location of the lines be decided upon, but the number of calls per day which may be expected over each line must be estimated; not only must the number of calls which are expected be correctly determined, but the time of the day during which these calls may be expected must be arrived at in some manner. Even more than this must be done, because it is necessary not only to know all of these facts, but also it must be known where the calls are to go. We must also know what proportion of these are likely to be toll calls, what proportion long-distance calls, and various other factors of like nature must be determined.

There can be no doubt that telephone development, as thus viewed and as correctly viewed, presents abundant opportunities for errors, and that such errors must lead to expenditures of large sums of money, which, if infallible data were obtained, would not be required.

But conceding all this, what is the alternative method which we can follow? It is obvious that what are erroneously called "common sense" methods might be employed. Buildings might be erected in various locations in a city, chosen after an inspection of the region; they might be substantially constructed and provided with switchboards. These buildings might be joined together by subways, and in the subways cables could be located. Suburban and long-distance, trunk-line subways might also be constructed, and there is no doubt that according to such a plan telephone business could be carried on.

But have we, after all, in following this method avoided answering any or all of the questions with which the study undertakes to deal? Most certainly we have not, and while it might not be appreciated, every step taken in this so-called common sense method really makes a direct, though unconscious and unintelligent, answer to all of the questions propounded and dealt with in the formal study.

If, following this common sense method, it is decided to erect at a given location a central office building with a switchboard of a given size, this office must be intended to serve a district of some definite form. If, as would of course be the case, other central office buildings are erected at other locations, they too must be constructed with reference to fixed districts, and their number must be determined with reference to the expected growth in subscribers; so that after all the magnitude of the expected growth is a factor which is unconsciously dealt with.

But in determining upon the size of the switchboard and its construction, whether we realize it or not, a definite, though unwitting, answer is made to the questions of what shall be the rate of calling, what shall be the destination of the calls, what shall be their character, and at what time they shall occur. The switchboard and building must be planned for some set of conditions which can be established only by data of this character. Merely ignoring these questions and erecting the switchboard and arranging central offices without making a study does not avoid answering the questions, for by the construction carried out a direct and unequivocal answer to all of these questions is made, yet without giving consideration to any of them or even recognizing their existence.

So it is with subway construction. It is easy enough, after central offices have been located, to plan for a subway joining those offices, but somebody must answer the question of how many ducts shall be provided in this subway. This can be done by the method outlined in describing the study, or it can be determined at the time by somebody who is opening the streets. It may be done, on the one hand, by engineers after careful study with all of the facts before them, and after having analyzed the statistics of the past and having exhausted all possible methods of throwing light upon the subject; or it may be done by a man in the street with a pickax.

Those who would follow the pick-ax method would not avoid questions which the engineer has recognized and has undertaken to answer. They would, by the number of ducts they would put down and by the character and magnitude of the other construction, give their answer to all of these questions without having considered any of them. As to which of these two methods should be followed, the telephone company must decide.

Thus far in the outline of that part of the telephone engineer's duties which pertain to development studies, the author dealt more particularly with the physical features of the work. In addition to these, telephone engineering has to deal with commercial questions which, of themselves, would seem to be only remotely connected with the work of the telephone engineer, but which really vitally affect it.

Telephone engineering presents more factors of this nature than are to be found in many other branches. For example, a telephone toll line and switchboard system might be designed in accordance with the highest state of the art and constructed so as to give the best efficiency, and yet by the action of the business management, causing the adoption of what might seem to be a reasonable commercial practice, the operativeness of the switchboard system might be totally destroyed.

Consider what would happen to the present toll board at Cortlandt Street, in New York, operating on the recording basis, using the two-number method of calling, if, by some change in business plans, the particular-party method in use extensively in many other localities were adopted. This would require a second set of operators, the radical reconstruction of the entire toll-board plant, the abandonment of the direct-line trunking method, and necessitate the handling of toll lines from toll boards. It would increase the number of toll boards from one, occupying one floor, to five or six on as many floors, and increase the number of operators in like proportion.

Another example, perhaps even more far reaching in its effect upon the work of the engineer, is the question of whether the telephone company shall charge for its service on the flat rate plan, or by messages as is now generally the case in this neighbourhood.

Under the flat-rate method of charging, in large cities, the more times the customer uses his telephone during the day the greater is the expense to the telephone company. This is due not only to the increased number of operators required, but also to the increased switchboard sections needed for them and to the increased trunk-line plant. By the method of flat-rate charging there is no motive for the telephone company to encourage an increase in the number of calls. For this reason a flat-rate plan would have to be so engineered and the rates would have to be so established that extension stations, desk stands, and other auxiliaries tending to make the use of the telephone easy and therefore more frequent, must be discouraged.

The consequence of the excessive use of the subscribers' line which such a rate engenders, is that the busy calls attain such serious proportions that it is difficult, if not absolutely impossible, to give satisfactory service. This trouble from busy calls has at times attained such serious proportions that engineers in various places have exerted extraordinary efforts to mitigate the evil, but without success.

This difficulty having been caused by commercial methods could not be overcome by the engineer employing physical methods. The solution of this difficulty lay with the business management and consisted in the adoption of a proper system of message rates. As soon as the message-rate system was adopted all of these difficulties disappeared, and many positive advantages not even suspected as residing in the message-rate plan developed.

Under the conditions obtaining in our large cities, the relief of an overloaded line can be obtained only at the expense of a second line, which in most cases meant doubling the cost of the telephone service. For this and many other reasons the desired relief could not be obtained under the flat-rate system.

By introducing into the large cities the message-rate system, and by placing proper limits on the load which should be carried upon one line, and by providing a graduated system whereby additional lines could be obtained on a basis proportionate to the amount of their use, relief from this overloading was afforded. More than this, under the message-rate system it is obviously for the interest of the telephone company to encourage the use of the telephone in every manner. For this reason it became feasible and desirable to install as many auxiliary instruments as possible. This was accomplished by providing for those who required two or more lines, a switchboard located at the subscribers' premises, this switchboard being so constructed that as many local stations as might be required could be installed at a moderate equipment charge.

Nothing more forcible than these examples needs to be mentioned in order to show the intimate relations between telephone engineering and business management.

From time to time, engineering methods involving new principles are brought forth. These, when found to affect the methods of the business office, should be submitted to the business management with a full and clear statement of their bearings upon the commercial work of the company. On the other hand there are, from time to time, business proposals and commercial methods which are under consideration by the business management of telephone companies and which, apparently, are only remotely or not at all related to engineering. In view of the many unexpected and important reactions which these proposals may have upon the engineering of the telephone plant, it becomes of the first importance that they should be scrutinized carefully from an engineering point of view, unless it is conclusively apparent that they will be without effect upon the engineers' plans.

Other instances besides those enumerated might be adduced, such as the effect of the three-minute toll period method of charging upon the various features of suburban trunking methods; and the complicated and disastrous reactions produced by the introduction of many of the party-line systems.

The author next considered the design and construction of the varied machinery constituting the modern telephone central office apparatus, indicating the character of the work which devolves upon the telephone engineer.

During the ten years just passed, a revolution has taken place in the design and construction of telephone switchboards, the magneto switchboard, so-called, having given way to the common battery switchboard.

In the magneto system, signaling from the subscriber's station to the central office was accomplished by means of a small alternating-current generator turned by hand, and the current supply needed in the working of the transmitter was obtained from a few cells of primary battery located at the subscriber's station. With the introduction of the common battery system, the magneto generator and the primary battery were dispensed with, the current supply for operating the transmitter, as well as that required to enable the subscriber to signal, being drawn from a large storage battery located

at the central office. In the case of a 10,000-line switchboard, the storage battery must be capable of giving an average discharge of 500 amperes; and to insure proper working conditions, it must be capable of giving a safe discharge as high at 2000 amperes. For charging such a battery as this, suitable machines must be employed, and these must be present in duplicate or triplicate. The standard machine used for charging a battery of this type delivers 1000 amperes.

The introduction of currents such as these, and the introduction of these machines and of a large number of auxiliary machines generating currents for special purposes, have resulted in the creation of a power plant at each central office, upon which the operation of the telephone switchboard and apparatus is wholly dependent. The protective methods, also, while following the general principles of such methods in electric light and power practice, are vastly more refined in their working, and call for a hitherto unattained degree of precision in the manufacture of such apparatus.

While the storage batteries and auxiliary machinery employed in telephone power plants are far from equalling the magnitude of similar apparatus employed in electric light and power stations, nevertheless they have become such a vital element of the successful engineering of a telephone central office, that they require on the part of the telephone engineer a special knowledge of this branch of electrical engineering, which was formerly not requisite.

Where a dynamo is to be constructed to operate incandescent lamps, let us say, certain minute fluctuations in the potential of the machine are permissible. Were such a machine, however, to be used in connection with telephone circuits, these fluctuations in potential would be sufficient to produce such constant humming in the telephone as to render it inoperative. Hence a greater refinement of the construction of these machines in this respect is imperative where they are employed in the telephone power plant.

So it is with the storage battery, where a number of telephones are supplied by current from one storage battery; even almost infinitesimal changes in the voltage of the battery might be propogated to the telephone lines connected with it and produce disturbances. For this reason, storage battery practice from the telephone point of view presents problems which are different from those encountered elsewhere. The requirements of the telephone art have called also for special refinement in the design and manufacture of the lamps for signaling.

While the common battery switchboards as now used in all of the large central offices represent a revolution in methods as compared with the magneto system, there are certain elements formerly used in the magneto system which have persisted. Among these is the multiple board principle. This principle, as is well known, consists in extending a number of lines to different points in the switchboard so that it is possible to connect with them at any one of these points.

The multiple system is opposed to the transfer system, which is one wherein the lines are not so extended or multipled to different points, but proceed directly to a special location from which trunk lines extend to other parts of the switchboard, so as to provide for making the necessary connections. No type of switchboard of any magnitude is now seriously considered which does not in a very substantial manner utilize this multiple principle.

In a self-contained central office, with relatively few trunk lines extending to other offices, it is found most economical to multiple all of the subscribers' lines to each section of switchboard. In very large cities where a number of central offices are required and where the amount of trunking between the different central offices is relatively large, the advantage of multipling the subscribers' lines to each section is not so apparent as in the case of the self-contained office, and this fact has led many to the conclusion that for such situations multiple boards are not adapted. While it is true that the advantage of multipling the subscribers' lines to all the sections of the switchboard becomes less and less as the percentage of trunking increases, it is still a fact that the point is never reached where the multiple principle should be abandoned entirely.

The truth of this proposition may be easily established by assuming that in a large city all the calls must be trunked, and that none of them are local to the office in which they originate. In such a case as this it is obvious that nothing could be gained by extending all of the subscribers' lines before each of the operators. On the other hand, it is still essential that the outgoing trunk lines should be extended, or multipled, before all of the subscribers' operators, and all of the subscribers' lines should be multipled before the trunk operators. While the case of an office without any local calls is one which could not occur in practice, there are situations in which the amount of local calls is so small that it will not pay to multiple the subscribers' lines to all of the subscribers' operators. Just when this point is reached is a question to be determined in each case.

Thus far, the instances where it has been found possible to omit this multipling of the subscribers' lines are few, but as time goes on the number of these cases must increase; but at no time, so far as can now be seen, will the point be reached where the multiple principle itself will be abandoned. Even in the automatic switchboards, which constitute one of the most interesting of the recent developments, the multiple principle is found to be essential to the working of all types of automatic boards thus far proposed, wherever the switchboard is of any substantial magnitude.

The merits of the various automatic switchboard systems which have thus far been installed were next discussed. Taking into account all of the factors involved, and which go to make up the total annual charges which could properly be placed against the automatic switchboard system on the one hand, and the manual system on the other hand, leaving out of account switchboards suitable for use only in small villages and making comparison up to switchboards of 10,000 lines capacity, the author found that the annual charges upon the automatic system are substantially greater than the annual charges upon a manual system operated on the common battery multiple plan. From the standpoint of costs, therefore, the automatic system fails when placed in competition with the common battery multiple board operated manually.

A careful investigation was also made to determine whether the automatic system possessed any advantages of working over the manual system which might compensate for the extra annual charges which its use necessitates. For this purpose there were made about 7500 service tests on manual switchboards and automatic switchboards operating under practical conditions in different parts of the country.

The results of these tests showed that the manual system possessed a most substantially greater degree of reliability than the automatic system. The difference in speed of connection between the two systems was so small as not to constitute a practical factor, the time elapsing between the start of the call and the answer of

the called subscriber being in the case of the automatic system 19.9 seconds, and in the case of the manual system 21.7 seconds. These figures include the time taken by the subscriber to answer, and even this small difference of time was found to be due to the fact that the subscribers whose lines were tested answered somewhat quicker in the automatic system than in the manual system.

These tests showed that the automatic system possesses no practical service advantages over the manual system, and that it contains no elements sufficient to warrant any part of the extra cost which its use involves. All of the foregoing relates to switchboard systems smaller than 10,000 lines, no automatic switchboard of larger size having been installed.

In order to determine whether for systems larger than 10,000 lines the automatic principle might be applicable, a system of 100,000 lines was assumed to be equipped with automatic switchboards, and was compared with a similar system equipped with common battery multiple switchboards operated on the manual basis. Here again the comparison was in favour of the manual board, both in point of annual charges and in respect to the service.

So important, also, are the large number of adverse factors which must be charged against the automatic plan of working, that it is safe to say that even if the annual charges on the automatic system were substantially less than those on the manual system, they would constitute such a serious objection to the automatic system as to bar its use.

The author had no hesitation in saying that no plan thus far employed, which requires that the subscriber should operate a machine and send his call automatically to the central office, can successfully compete with the plan which requires that the subscriber should remove the telephone from the hook and send the call orally to an operator at the central office.

To the proper choice of material as well as to their proper arrangement in the plant, the telephone engineer must devote serious and constant attention. All materials which are permitted to form a part of the telephone plant must be carefully studied by him so as to obtain out of all those possible to use, those which offer the best combination of first cost, durability, low annual charges, and high efficiency.

Intimately connected with this matter of the choice of material, and making the specifications for them, is the complementary function of accepting or rejecting that which is offered. The drawing up of the specifications must be attended to with the utmost care so that they may be placed in the hands of the purchasing agent, and be sufficiently intelligible so that any manufacturer or person skilled in the art can understand their purport and supply without further information the articles desired.

Not only must the article desired be clearly described, but the language used must be such that no material other than that desired can be furnished. At the same time, great care must be exercised that undue and excessive requirements should not be specified, otherwise the cost of the materials would be unnecessarily increased.

In addition to these more typical functions of the telephone engineer, there are constantly arising questions demanding special investigation. While their range is so extended as to cover almost every field of engineering in scientific progress, and while the telephone engineer cannot be expected to be expert in all departments of scientific investigation, he is required to direct such investigations, employing, as his judgment may dictate, experts in various departments to report upon those phases of the work in regard to which they may be best qualified to speak.

The relations of the telephone engineer to the telephone organization at large, can best be understood by stating that the telephone engineer in every well-organized telephone company must, in the first place, broadly determine all of the important features of the plant of the company, and he must in detail decide what shall be the nature of the construction and the method of operation of every single item which constitutes the physical property of the telephone company.

If there be any defect in a cable, in the design of a switchboard, or in the construction of a plant, the fault lies with the telephone engineer.

That this must be so will be made clear by describing the method which obtains in well-organized telephone companies of getting from the board of directors the necessary appropriations for carrying out all construction and reconstruction work. Under such conditions a development study will have been made and will have been approved by the business management.

A case will be made out setting forth the nature of the work, and the necessity for it, and an estimate showing its cost and a specification describing the work in detail will be submitted to the management, and if in proper form, it will be duly approved.

This work must be supervised, as far as may be necessary, by the engineer, and upon its completion he must accept it or reject it. Having accepted it and having made a report to that effect to the business management, the transaction is completed. By this acceptance of the work, the engineer assumes full responsibility for its efficiency.

So it is with other features of the work. From beginning to end the engineer is thus placed in a position to exercise a veto power upon any adverse methods which might otherwise be allowed to creep in.

The carrying out of this estimate system in this way places final responsibility upon the engineer and recognizes in the most practical manner one of his most important functions, which is to co-ordinate the various elements which must be put together in such a manner as to avoid conflict and produce a consistent symmetrical organism, each part of which will be designed and constructed with due reference to the functions which it must perform, and also with due regard to the functions and importance of all other elements in the system.

In order to exercise proper co-ordinating functions, it is essential that the engineer should be placed and should maintain himself in such relations with all of the departments of the telephone organization that he may get from them and fairly consider all of the projects and ideas pertaining to the design, operation, construction, and maintenance of the plant which naturally originate in such departments when they are conducted with proper efficiency.

Viewed from this standpoint, it will be seen that while the function of the engineer with relation to the plant is of the utmost importance, nevertheless the work of the traffic, maintenance, construction, and other departments has such an important bearing upon the whole question that the successful engineering of a telephone system must be regarded not only as the work of the engineer himself, but as the work of all of the other departments concerned. Not only this, but what is still more important, the successful engineering of a telephone plant depends upon proper business management. Without an intelligent, progressive, and broad gauged business management, there cannot be good telephone engineering.

DISCUSSION

After the reading of Mr. Carty's paper, T. D. Lockwood, manager of the patent department of the American Telephone & Telegraph Co., opened the discussion.

Mr. Lockwood said in part, that he always felt like congratulating the telephone engineer, because he has so many kinds of engineering to deal with, not merely electrical engineering, but every other kind of engineering. This is more than hinted at in the paper of the evening, because the telephone engineer has to touch every other sort of electrical engineering somewhere.

He has to deal with the currents used in incandescent lamps, in arc lamps and in power plants. He always had to do it, but mostly in the early days he did it as a means of protection, to protect against different sorts of attacking currents, of varying potentials, and that is an interesting point for us to remember.

Referring to the author's estimate of the life of the central office switchboard, which was placed at fifteen years, the speaker thought it in some respects unfortunate that the life of the telephone switchboard is not more than fifteen years, because the rate of telephone switchboard progress is quite as fast as that, and if it did not die a natural death at the end of an average period of fifteen years, it would soon, thereafter, reach the smashing age. He thought the average life was less than fifteen years.

In closing his remarks Mr. Lockwood asked the author to give the meaning of the terms, "two-number method of calling," and the "particular-party method of calling," used in his paper.

Prof. M. I. Pupin referred to the paper as a catechism of telephone engineering, saying that he would study it carefully and learn it more or less by heart.

As to what constituted a good telephone engineer, he could not say.

The same thing could be said of every kind of engineer. He is not necessarily a good mathematician, physicist or chemist. In fact, if you talk to them, their ignorance on any specialty will be apparent. But if the questioner is a mathematician or a physicist and he feels that he knows a great deal more than they do in regard to mathematics and physics, just try to work off a poor theory on them and observe how you will fail.

They somehow have the knack of seeing through a thing a certain way and arriving at conclusions, the methods of which are beyond the comprehension of ordinary men; they are experts, specialists. An engineer is a man who knows a little of everything that bears upon his profession, but he knows it very well. He does not pay much attention necessarily to specialties, but he knows absolutely the relation of things to each other; he must have a wonderful prospective of things that are in his profession.

As far as the electrical side of telephone engineering is concerned, Professor Pupin said, we have the great problems of insulation, isolation, and lamination. If the electrical circuits or the magnetic circuits are coupled together, cross-talk results; hence the necessity for insulation and isolation.

Then, as to lamination, the electrical circuits and magnetic circuits must be arranged to give the least possible loss. If the conductors are not laminated there will be such a loss that the whole plant will be very inefficient, no matter how much the cables, switchboards and building may have cost, or how well the insulation may have been attended to. To be sure, in all kinds of electrical engineering, insulation and isolation of the currents must receive attention.

We try to prevent magnetic flickering, and electrostatic induction in all kinds of electrical engineering, and we have to laminate in all kinds of electrical engineering; but in telephone engineering, such high frequencies are dealt with that these things have to be carried to the limit. It is working to the limit that makes telephone engineering extremely elaborate and so extremely exact.

A little loose contact in ordinary electrical engineering will do no harm, as the voltage is high, and it does not matter if the circuit has a slightly loose contact; but in telephone engineering, where the voltage is excessively light, the slightest loss of contact may cause a great deal of trouble, because it will induce at low voltages a much higher resistance to the circuit than it would if the voltage were high.

Telephone transmission is carried by a wave, and when it gets to a loose joint, it has as much chance to go back as in any other direction, and there is a deflection, and a loss due to deflection is a serious matter. The same is true with regard to the insulation; extreme care is necessary.

It is the same with the laminations. Ordinary electrical engineering power stations work between 14 and 20 mils. In telephone engineering, iron plates and iron wires only one mil thick are employed. The power-transmission electrical engineer desires as high permeability in iron as possible. The telephone engineer, on the other hand, wants the permeability to be low, not above a certain upper limit.

If the lower limit of permeability was 1000, very many of the most scientific telephone apparatus would be impossible, and long-distance telephony would in all probability be out of the question. But telephone engineers found a microscopic limit in which the permeability of the iron is only 200 or less, and they must be constantly on guard not to extend their operations outside of this limit.

The next speaker, B. Gherardi, of Brooklyn, said that there is a phase of telephone engineering which the author had necessarily touched upon but briefly, namely, the engineering which, as a matter of administrative efficiency, should be done in the various executive departments of the organization, such as the department under the control of the superintendent of traffic, and the department under the control of the superintendent of construction.

One of the functions of the traffic engineer is to watch carefully the growth of the business with reference to the requirements for additional equipment of all kinds for switchboards, and a proper length of time in advance to report when additional equipment will be necessary, and to what extent.

Among some of the factors which the traffic engineer must watch closely in connection with each large switchboard, are the number of subscribers' lines available in the multiple; the number of switchboard positions available for subscribers' operators, and for trunk operators of various classes; the number of incoming trunk cords available for incoming trunk lines of various classes; the number of call-wire circuits available for calling circuits; and the arrangement of answering jacks so that it may be possible to give all operators at the switchboards proper loads.

Another very important function of the traffic engineer is to watch the constant growth of the business trunked between various offices and handled over toll lines between various sections of the territory, and to originate recommendations for additional trunk circuits that may be required to take care of this business. Numerous cases arise also where it is necessary that detail studies should be made of various operating methods. It is, in general, the traffic engineer's duty to do such work.

Similarly, in the construction department, there is necessity for a construction engineer who performs in that department, functions prac-

tically similar to those performed by the traffic engineer in his department. One of the important duties of the construction engineer is to keep constant watch of the cable situation, in order that the demands for service may not exceed the facilities. All these matters are finally referred to the chief engineer for his decision.

From an engineering standpoint, Mr. Gherardi thought it safe to characterize the development of an organization having engineers in the construction and the traffic departments as one of the important steps that lead to efficiency of the operating organization as a whole.

To C. P. Steinmetz, telephony had always appeared a very important matter. To consider how the speech sound can be transmitted over long distances by current so minute that only with the most sensitive oscillograph has it been possible to record them on the photographic film. There is one very important and instructive feature in telephone transmission for the consideration not only of the telephone engineer, but of the electrical engineer in general—both the transmission of power and of speech are essentially electrical transmissions of power.

In electric power transmission, however, the problem is to deliver at the end of the line as large a percentage as possible of the power which has been sent into the transmission line. In telephone transmission, the problem is to deliver at the receiving end of the line the electric power with as nearly as possible the relative proportion of the harmonies of the complete wave as was sent into the line by the transmitter. This is the great difficulty in long-distance telephone transmission.

The telephone is such a sensitive instrument that enough power to produce sound could be transmitted almost to any distance. Sound could be transmitted, but not articulation, that is, those higher harmonies of the current wave which constitute the difference between the different sounds of the letters. It is a question of eliminating destruction or deterioration of the wave especially with which the telephone has to deal.

Professor Pupin said, that what Mr. Steinmetz had stated in his interesting and instructive remarks might be expressed in the following words:—the distinction between ordinary power transmission and telephone transmission is this:—With the ordinary power transmission as large a power factor as possible is desired, while in telephone transmission as small a power transmission as possible is desired, a comparison he had used several years ago before the Institute.

The author, in replying to Mr. Lockwood's question, said that the two-number and particular-party business is an expression well known among telephonists, but he surmised when he used the terms in the paper that they might not be understood by those in other branches. He thought he would run in some new terms, as the engineers in other branches sometimes do and leave others to find out the meaning the best they can.

What was meant by the term might be better expressed by calling it member calls, instead of two-number calls. For instance, the suburban business is handled on the number call basis, for the subscriber in Newark just the same as for the subscriber in New York, although the method of handling the call may be different.

In many stations for suburban business, the plan is to call by name for the particular party at the office called, and if the party is not in, there is no charge. The idea seems to prevail in the minds of the people who use that system that they save money by not being charged for that call, but it is obvious that the cost of the call must and does fall on telephone users.

Therefore, in the neighbourhood of New York the trunk line plant and the method of operating have been managed, as far as possible, to require the calling by numbers. That enables the caller to get through more quickly, more reliably and more cheaply.

In regard to what Dr. Pupin said about working to the limits in telephony, it might be said that the limits of speed of underground cables had been reached, and the limit had been practically reached on the long distance and the underground toll line business, and there had been great questions as to what could be done about it, when, at the opportune moment, Dr. Pupin arrived with his loaded conductor invention that solved the problem.

The meeting then adjourned.

The First Telephones in Russia

According to "Sound Waves," Charles O. Harris, of the Utah Independent Telephone Co., was sent abroad by the International Bell Telephone Company in 1881 to introduce the telephone among royalty and the higher classes in Europe. In Russia the new "toy" was received with the greatest favor, and orders were given to install it in all the royal palaces.

The Czar then was Alexander III. He was especially fond of the theatre and opera, and so he had the palace at St. Petersburg connected by telephone with all the leading theatres. Even at that early day there was an arrangement by which the dialogue of a play or the music and words of an opera could be transmitted from the theatre to the home by means of the telephone. In the palace, a series of receivers were arranged about a circular seat of cushioned velvet, and here the Czar and several of his friends could enjoy a play without leaving the library.

As soon as the fashion was set by the Czar the telephone sprang quickly into popularity in all the principal cities of Russia. They not only were used in the government buildings, but also in the business houses of Moscow, Warsaw, St. Petersburg, Riga, and Odessa.

Count Tolstoi was among the others who fancied the theatre arrangement so much that he had one installed in his house. The system was a trifle different from that in the royal palaces. The circular arrangement of the receivers was not followed, but the guests, when enjoying the theatre or the opera from his home, were seated on a long velvet settee, the receivers being attached to the wall.

The terms of the concession or franchise of the International Bell Telephone Company carried with it the use of the plant for twenty years, after which it reverted to the government. These conditions have been carried out, and in 1902 the government assumed charge of the entire system. Since that time the various plants have been reconstructed and modern common-battery apparatus is now universally used, which is a far cry from the old style grounded line system, using the original Gilliland series drop magneto board.

In a paper read recently before the American Society of Refrigerating Engineers, Prof. R. Carpenter said that motor-driven refrigerating plants smaller than 1 ton capacity, down to those of about 300 pounds capacity, are used in residences in cities and in country clubs, and private residences so situated that ice is difficult to obtain, but where electric power is available. The use of any other power than electric is not usually practicable, unless in the case of a small gasoline engine, which, however, would require more knowledge of machinery than is possessed by the average servant.

Illuminating Engineering

By L. B. MARKS

An Address Delivered Before the Illuminating Engineering Society, New York, on February 13

THE movement to bring about the formation of this society was started only a few months ago. The preliminary meeting was held on December 21, 1905, and another took place January 10, 1906. At these meetings, the opinion of those who attended was practically unanimous that the time was ripe for the formation of a separate society devoted to the advancement of the science and art of illumination. The interest taken in the cause from the start has been most keen, and the fact that in the course of a month, over 150 members have been enrolled, and that applications for membership are coming in daily, unsolicited, from various parts of the country, is evidence that there is an urgent demand, I might even say a thirst, for the information which it is believed this society will be the means of disseminating. The present membership is distributed among gas and electrical engineers, architects, fixture designers, and various interests connected with the production of lighting auxiliaries.

PRESENT STATE OF THE SCIENCE AND ART OF ILLUMINATION

Applying the term illumination to the use, in contradistinction to the production, of light, it may be truly said that while great strides have been made in recent years in the development of almost every detail concerned with the production of light, illumination, particularly from an economical standpoint, has been sadly neglected.

Broadly speaking, the electrical engineer has concerned himself with improving the efficiency of the generating apparatus, and cutting down losses in the transmission of power, but after his wires have reached the point at which the electric current is to be transformed into light, his engineering skill has not, as a rule, been applied. Similarly the gas engineer has been busy with questions involved in the manufacture and distribution of gas, while the problem of obtaining the maximum value or most effective use of the illumination delivered at the burners has been relegated to a secondary position.

So far as interior illumination is concerned, the lighting layout has been left largely to the architect. It is he who usually prescribes the number and location of outlets for the light sources, specifies the number and candle-power of the lamps, and designs or selects the lighting fixtures and accessories. Very often these specifications are completed before the colour scheme of the interior has been decided upon, with the result that the degree of illumination obtained may fall far short of what is needed in cases of dark-coloured interiors, or be excessive in the case of light-tinted rooms.

The natural tendency of the architect is to make the economical side of illumination subservient to the æsthetic, while, on the other hand, the tendency of the engineer is to consider only the question of economy. It is an encouraging sign of the times that the architect and the engineer are gradually drawing closer together in dealing with problems involving both the scientific and the artistic side of illumination.

Though much attention has recently been given to the subject of globes, shades, and reflectors, the fact still remains that unshaded or inadequately shaded lamps are the rule rather than the exception. In considering the present status of the science and art of illumination, there is perhaps no question that is in need of more immediate attention than this one. The practice of placing lights of excessive intrinsic brightness within the ordinary field of vision, is so common as to cause grave apprehension, among those who have studied the question from a physiological point of view, that our eyesight is suffering permanent injury.

That the percentage of children with defective eyesight is growing year by year, is a well-known fact. According to oculists, the strain on the eye caused by bright lights is in a large measure responsible for this condition. Those who have been subjected to the painful glare of the bare lamps used for illuminating our electric cars will attest to the visual discomfort caused by the subjection of the eye to an unshielded source of light, even as small as a 16-candle-power lamp.

Much of the trouble due to this cause would be removed if the light sources were concealed, and the illuminating power from them derived from reflected, rather than from direct, rays. Happily the tendency of modern illumination is in this direction.

From an economical standpoint, the correct disposition of the light sources and the use of the most suitable reflectors are of commanding importance. It is not uncommon to find instances in which adequate consideration of these two questions would result in largely increasing, and often more than doubling, the useful illumination.

Both electric and gas supply companies are alert to this situation, and are now giving these questions more serious consideration than ever before. The far-sighted manager of the supply company sees that it is to his ultimate advantage to assist the consumer in obtaining the very best illumination of his premises at the least expenditure of money for electricity or gas. In view of all this, it is extremely desirable that complete and authoritative data be obtained as to the amount and character of illumination best suited for individual conditions. At the present time, there is a lack of really valuable up-to-date information on this subject, at least so far as published records go; moreover, much of the information that is available is widely scattered, and often inaccessible.

The performance of lamps for street lighting and illumination of large open spaces has not been adequately recorded in papers bearing on this phase of the science of illumination. In view of the lack of complete data on this subject there is a wide difference of opinion to-day as to which of several illuminants is best suited for certain cases of streets and country roads, illumination and economy being considered.

The progress of invention in lamps and lighting apparatus has been so rapid that engineers have found it difficult to keep abreast of the times in the question of illumination. Only a comparatively few years ago the carbon filament incandescent electric lamp, the arc lamp (open or enclosed), and the ordinary gas flame

were the only illuminants with which we had to deal.

To-day we have besides these, among electric lamps, the incandescent lamp of the Nernst type, the mercury arc of the Cooper Hewitt type, the vacuum tube lamp of the Moore type, the impregnated carbon or "flame" arcs, the magnetite arc, and others; and among the gas and oil lamps, we have the mantel burner lamps of the Welsbach and other types, the oil lamps with forced air draught, the acetylene flame, and several others.

The amount of light, and especially of electric light used in the United States, has grown by leaps and bounds. The consumption of gas for illuminating purposes has also largely increased, the introduction of the mantel burner having given a great stimulus to the gas lighting industry. The place of the acetylene light has been firmly established, and the extended introduction of acetylene plants in the past few years is worthy of special note. The approximate amount of money that is spent by the consumer annually in the United States for illumination by electric light, gas and oil is as follows:—

Approximate Cost of Illumination to the Consumer per Annum in the United States* (1905).—Electric light, between $100,000,000 and $120,000,000; coal and water gas, between $35,000,000 and $40,000,000; natural gas, $1,700,000; acetylene, between $2,500,000 and $3,000,000; oil, $60,000,000.

At a conservative estimate the consumer is spending a total over $200,000,000 a year for lighting in the United States. Of this amount, I venture to say that fully $20,000,000 are wasted—absolutely wasted, so far as the amount of useful illumination delivered for the money is concerned. No one who has made a study of the subject can fail to see glaring examples of this waste at every hand. It is not at all uncommon to find in electric lighting that 25 per cent. of the light that is furnished is lost so far as any useful purpose is concerned, by reason of improper disposition of the light sources or unsuitable equipment of lamps, globes, shades or reflectors. In gas lighting, though the conditions are quite different, the same criticism in a measure holds true.

AIMS AND OBJECTS OF THE SOCIETY

It is one of the aims of this society to assist in remedying the conditions just referred to, and to point out in what way the best illuminating result may be obtained from any source of light, be it electric, gas, oil, or candle. With this object in view, the theoretical and the practical side of lighting will be given full consideration, and the æsthetics of the question studied alongside of the economics.

The society will aim to gather into its fold the various interests that are identified with the development of the science and art of illumination in all its phases. The specialist in illumination, the electrical engineer, the gas engineer, the architect, the designer of electric and gas fixtures, globes and reflectors, and the decorator will meet on common ground to discuss the question of illumination from all standpoints. The views, not only of the engineer, but also of the practician, will be courted. The keynote of the organization will be cooperation in all that makes for the good of the cause.

The society will undertake to gather authoritative data on the subject of illumination and render it readily accessible to those interested. It will hold monthly meetings during the year 1906, except in the months of July, August and September. At these meetings, papers dealing with all sides of the question of lighting will be read and discussed. These papers and the discussions, together with reports of special committees and data collected, will be published in the "Transactions of the Society" and distributed among the members.

SCOPE OF THE SOCIETY

The term "engineering," as used in the name of this society, unless viewed in its broad sense, is to a certain extent a misnomer, as the society will deal with some phases of illumination that may not properly be said to come within the distinct field of engineering, such, for instance, as the physiological side of the question. The society will be interested in every phase of the subject of illumination whether from an engineering point of view or otherwise, and will throw its doors quite as wide open to the layman as to the professional. It will not, however, deal with questions relating to the production or distribution of the energy from which the light is produced.

The question of candle-power rating and of nomenclature will receive attention. At the present time it must be confessed that the rating of lamps often leads to a great deal of confusion. Some lamps are rated on the basis of horizontal candle-power, some according to the downward candle-power, and some according to other standards. The society will endeavour to assist in bringing about a uniformity of candle-power ratings, and the general acceptance of certain nomenclature.

From what has preceded, it will be seen that the scope of the work to be performed by the society is broad. The committee on papers has suggested a number of subjects on which papers will be written for presentation before the society. Among these are:—"Principles of Interior Illumination with Special Reference to Cost, Colour of Light and Physiological Effects," "Street Lighting," "Illumination Data," "Lighting with Special Reference to Ventilation," "Lighting with Special Reference to Distribution," "Illumination from the Architect's Standpoint," "Æsthetics vs. Utilitarianism in the Design of Fixtures, Globes, Shades and Reflectors," "The 'Flame' Arc," "The Inverted Gas Mantel Burner," "Vacuum Tube Lighting," "Oil Burners," "Acetylene Lamps," "New Illuminants," "Candle Power Rating of Illuminants."

One feature of the work will be the consideration of special cases of lighting, as, for instance, the proper illumination of the assembly hall or auditorium, of the library, of the drawing room, of the factory, of the store, of the show window. The degree of illumination best suited to the individual conditions will form the basis of an investigation to be made at the instance of the society. Besides the subjects mentioned above, there are many others which need not be enumerated here, that come within the scope of the society.

RELATION OF THE SOCIETY TO OTHER ORGANIZATIONS

While the general subject of illuminating engineering comes within

* In the United States census report on central electric light and power stations issued in 1905, T. C. Martin gives the following data: Income derived from central stations in United States for year 1902 for sale of current for electric lighting, $70,138,147, of which $25,481,045 are for arc lighting and $44,657,102 for incandescent lighting. The number of arc lamps reported is 419,561. The number of incandescent lamps, 18,194,044. In addition to the above, I estimate that there are about 300,000 arc lamps in use in isolated plants. On the basis of 3½ hours per day, or 1100 hours per year average use per arc at an average cost of 3 cents per lamp-hour, the cost of lighting per annum by arcs in isolated plants would amount to $9,900,000.

Of the 45,000,000 or more incandescent lamps sold in the United States in 1905, it is estimated that about 70 per cent., or 31,500,000, were 16-candle-power lamps; about 7 per cent., or 3,150,000, more than 16 candle-power, and the balance less than 16 candle-power. On the basis of the data submitted in the census report above referred to, I compute that there were in service last year in isolated plants about the equivalent of 20,000,000 16-candle-power lamps. At 1⅓ hours a day, or about 400 hours per year average fuse per lamp, at an average cost of 3/10 of a cent per lamp-hour, the cost of lighting per annum by incandescent lamps in isolated plants would amount to $24,000,000.

According to the census bulletin on manufactures, issued January 3, 1902, the value of coal and water gas manufactured in the United States in the year 1900 was $69,432,582. The proportion of fuel gas to illuminating gas is not stated in the report, but is estimated at about 50 per cent. In the census report on natural gas, the value of natural gas produced during the year 1902 in the United States is given at $30,867,863. Only a very small percentage of the total consumption was used for lighting purposes. According to H. L. Doherty, the value of natural gas used for illuminating purposes during the year 1905 did not exceed $1,700,000. The figures for acetylene gas were estimated from data received from the Union Carbide Company. The figure for oil was obtained from the statistical department of the Standard Oil Company.

the purview of several other organizations, such as the American Institute of Electrical Engineers, the American Gas Light Association and the National Electric Light Association, the special field of work that has been mapped out for the Illuminating Engineering Society can hardly be said to fall within the province of any one of these organizations.

In the Illuminating Engineering Society, as has already been stated, the electrical engineer, the gas engineer, the architect, the fixture maker, and the decorator will meet on common ground. The work of each of these interests in the society will be concentrated on the subject of illumination. By such specialization the advancement of the art can best be furthered. Illumination is but a very small part of the field that must be covered by the American Institute of Electrical Engineers.

The American Gas Light Association and the National Electric Light Association are both concerned largely with questions of generation and distribution rather than utilization of the light produced. These societies meet only once a year. To adequately cover the ground and keep abreast of the times, a society devoted to the advancement of the science and art of illumination must meet frequently.

The Illuminating Engineering Society is in no sense antagonistic to other organizations that have to do with lighting. On the contrary, it aims to co-operate with such organizations to secure the best interests of all concerned.

Rotary Engines

THERE are certain problems in mechanical engineering, says "The Engineer," of London, which appear to be always on the point of being solved and always evading solution. Frequently they offer to the inventor a selection of many methods, and they are invariably of obvious desirability. Moreover, they have the fascinating characteristic that success always seems just within reach.

One of these problems is the rotary engine. We hesitate to say what a huge number of inventions of engines of this description have been protected since patent laws began. One very remarkable fact about the invention of the rotary engine is that it never ceases, and that the inventor of to-day never profits by the lessons of his predecessors. Reuleaux, in his classical work—he himself, by the way, if we remember rightly, believed the problem to be solvable—has arranged all types of rotary engines in a number of classes, and has given diagrammatic sketches of representatives of each type. We believe that, although his book is many years old, not a single new type could now be added to Reuleaux's list. Invention keeps going over and over the same old ground, sometimes without any attempt to meet the real difficulties of the problem, and sometimes with full recognition of the obstacles to success and praiseworthy efforts to overcome them. Yet the result is always the same. For a time a rotary engine, here and there, designed better than others has a short life, but they all, without exception, have hitherto disappeared, after a few years, into the limbo of history or into an intermediate condition of insignificance.

Years ago, before it was found that reciprocating engines could be run at very high speeds with success and efficiency, the rotary engine received more scientific attention than it does to-day, but since the stream of inventions runs as full as ever, it may be that some of our younger engineers have forgotten the few elementary facts that stand in the way of success. They are true of by far the greater number of designs. The first is the line contact; the second, excessive clearance; the third, friction produced by unbalanced steam pressure, or centrifugal force, on moving parts.

If anyone will look at a number of diagrams of rotary engines he will see that a favourite design is the "crescent chamber type." In this engine one cylinder is placed eccentrically inside another, and is provided with radial abutments of some form or another. In some cases the inner cylinder makes one of the abutments by bearing against the walls of the containing cylinder. The contact between two curved surfaces of different radii is a line contact, and steam tightness is impossible. That is an elementary fact which is daily forgotten. In some designs the abutments spring from the center of the inner cylinder, hence they are only radial to the outer cylinder in two positions, and, if their extremities are curved to fit the outer walls in these positions they will fit nowhere else, hence if line contact is to be avoided a flexible joint of some kind, with consequent leakage and complication, must be employed.

If in an endeavour to avoid the first difficulty the inner cylinder is removed some distance from the outer casing, and the changes in the contents between two radial abutments looked to for the propelling power, the clearance at once becomes formidable. The designer therefore finds himself in a quandary. In the one case he loses steam by leakage, in the other by excessive clearance. In another common type of engine, abutments are hinged either on the rotating members or on the fixed cylinder; if the former, they are driven out with considerable centrifugal force; if the latter, they are pressed in by the steam, frictional loss increasing in either case to an enormous extent unless provision, again with necessary complications, for removing these objections is introduced.

Again, there is the common type in which the revolving portion is cam-shaped, and an abutment either presses on it radially or obliquely. In either case one of two, or both of the following difficulties have to be met. Either the back of the projection is nearly radial, in which case, however quickly the abutment may fall, it cannot prevent clearance being excessive, or the projection may be curved and closely followed by the abutment remaining always in touch with it, when, again, it is difficult in practice, owing to the curvature of the abutment, to avoid line contact, as a few moments' consideration will show.

All older engineers who have studied the question at all are aware of these difficulties, and have long since given up the pursuit; but younger men, even amongst engineers, still spend their guineas year after year in the vain quest, and it is to them that these few remarks on one or two out of the many difficulties that beset the rotary engine are addressed. We have touched only two or three types, but we invite our inventors to study Reuleaux's pages, and to apply his lucid critical observations to their devices before they take out patents. One very important thing they must note, and that is that many rotary engines are reciprocating engines in disguise, having masses with alternating motions just as ordinary engines have, and hence lacking the very advantages supposed to be given by the rotary type.

The mines of the Black Hills, South Dakota, will soon be provided with electric power. This will make possible the working of mines which hitherto have been too isolated or have possessed ore of so low a grade that it did not pay to work.

Electrification of the Victorian railways in Australia is now under consideration. They are owned and operated by the State, and have a mileage, including sidings, of 4264.

Electrical and Mechanical Progress

The Oscillograph

THE electrical instrument known as the oscillograph may be most readily compared to the indicator of a steam engine, and the photographic reproduction of the wave form produced by its action,—the oscillogram,—has its most exact counterpart in the indicator card. Various methods have been devised by different manufacturers to provide a satisfactory method of observing or recording the wave forms of rapidly varying electric currents and pressures. The oscillograph, shown in the annexed illustration, is a most compact form of the vibrating loop type, manufactured by the General Electric Company, of Schenectady, N. Y.

Among the scientific requirements which have been met in this instrument are, short, free, periodic time compared to the periodicity of wave forms recorded; critical damping, that is, the free motion just ceases to be oscillatory; neglible self-induction; and sufficient sensibility. Quite as important, from an engineering standpoint, is the need of an instrument whose working parts are accessible and of sufficient size that they can be renewed and repaired by persons ordinarily skilled in the handling of testing instruments.

This oscillograph is similar to a D'Arsonval galvanometer, in that it has a current-carrying circuit, located in a powerful magnetic field. The part corresponding to the moving coil in the galvanometer is replaced by two small moving strips, which also act as a suspension and carry the mirror.

In a light-tight box, shown in Fig. 1, is placed a three-element galvanometer combined with devices for viewing, or photographically recording, current and electromotive-force waves. Each galvanometer element, or vibrator, consists of a single loop of very fine ribbon *B*, Fig. 3, suspended vertically in a powerful magnetic field. The terminals of the galvanometer are the ends of this

FIG. 1.—AN OUTSIDE VIEW OF THE OSCILLOGRAPH MANUFACTURED BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SHOWING THE PHOTOGRAPHIC AND TRACING ATTACHMENTS

FIG. 2.—THE INTERNAL ARRANGEMENT OF THE OSCILLOGRAPH PARTS

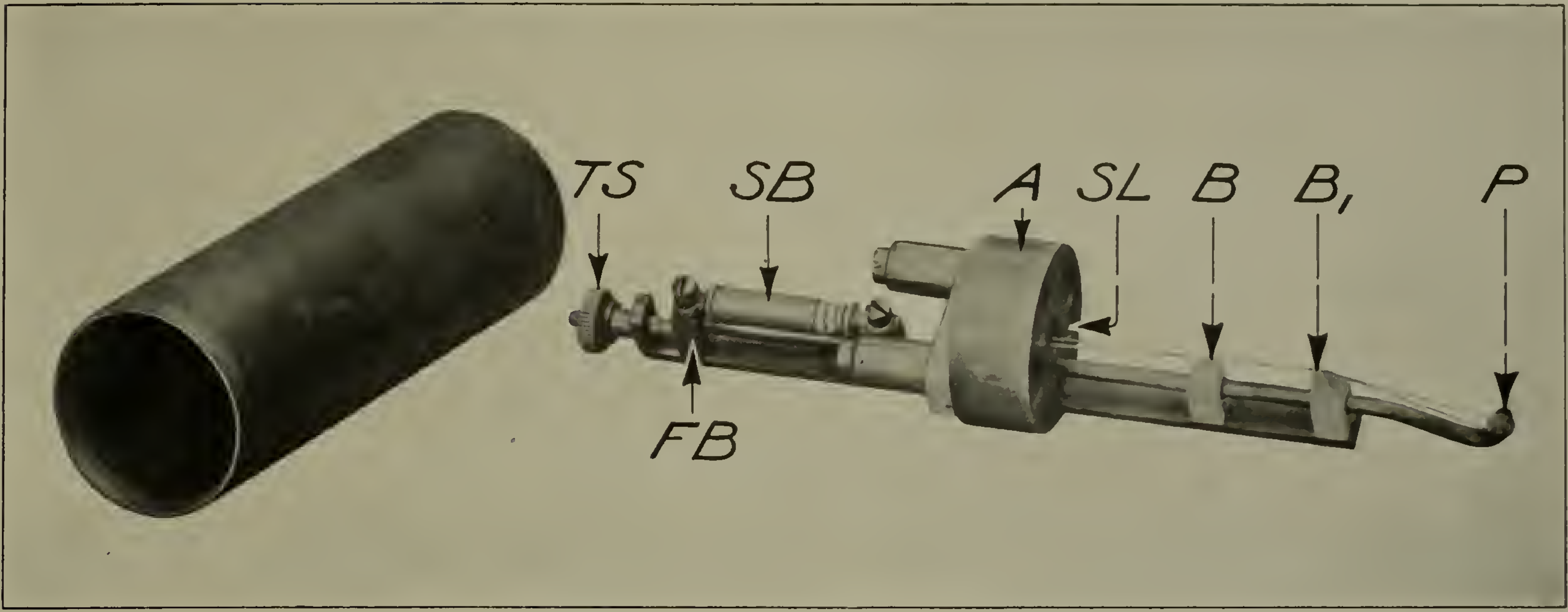


FIG. 3.—OSCILLOGRAPH VIBRATOR AND SHIPPING CASE. THE PARTS ARE: *TS*, *SB*, THUMB SCREW AND SPRING BALANCE TENSION ADJUSTER; *B*, B_1, BRIDGES OVER WHICH VIBRATOR RIBBON IS STRETCHED; *P*, PULLEY; *A*, TERMINAL BLOCK; *SL*, SLOT TO FACILITATE ASSEMBLING; *FB*, FULCRUM BLOCK

loop, which is held at its lower extremity by an adjustable pulley *P*.

With the exception of the magnetizing coils, each galvanometer element in the set of three is entirely complete, and can, therefore, be easily insulated. Each set of vibrating strips is exposed on all sides when removed from the containing cells, so that any required adjustments or repairs are most conveniently made. Adjustments are further provided so that even if the vibrating mirror is imperfectly attached it is possible to bring the image of the mirror into the desired place on the photographic film. The containing cell is filled with damping liquid, and the vibrating loop or strips are made of hard-drawn silver, with a silvered glass mirror. The latter is usually 80 by 20 by 10 mils,—large enough to be easily handled, and producing a better photographic record than a smaller mirror. Unless high period is absolutely essential, the manipulatory advantages of the larger size outweigh other considerations.

The optical system is shown in Fig. 4. A source of light, usually an arc lamp, is thrown by a lens upon the prisms *P*, *1*, *2*, *3*, and by them to the oscillatory mirrors *VM*, *1*, *2*, *3*. From these mirrors the rays are reflected horizontally to the photographic drum at the opposite end, or to the synchronous mirror *SM*, from which they are reflected upward to a surface where they can be observed or traced.

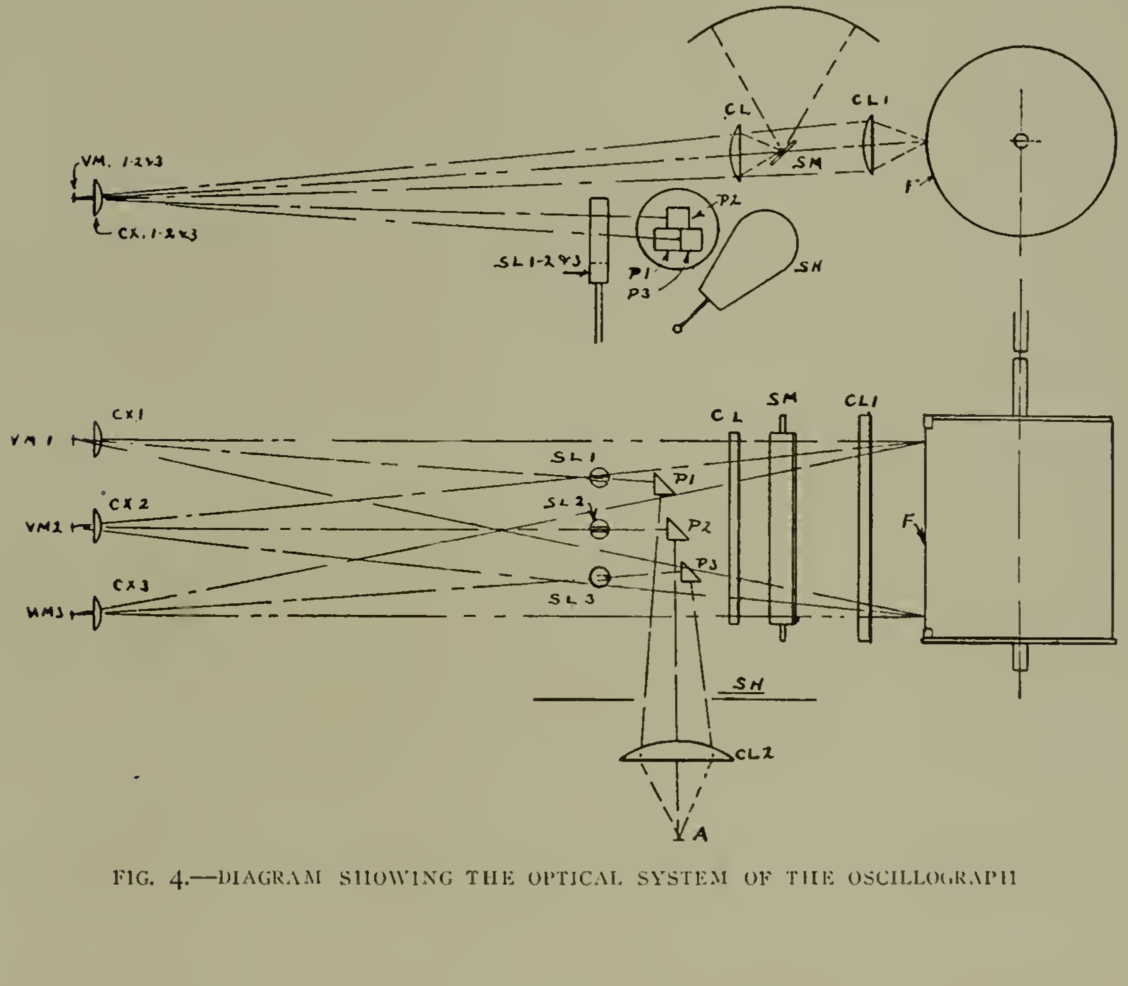


FIG. 4.—DIAGRAM SHOWING THE OPTICAL SYSTEM OF THE OSCILLOGRAPH

The vibration of these oscillatory mirrors produces three lines of light, the amplitude of their vibration measuring the strength of the current or electromotive force. To produce a wave photographically, a drum carrying a sensitized film is revolved in the path of these light rays, thus forming the abscissas of the projected wave.

The same shaft which carries the photographic drum operates a set of contacts which actuates a shutter interposed between the arc-light source and the condensing lens. This shutter-operating mechanism is so arranged that the shutter is open during one revolution of the drum. Devices are provided so that this shutter may be adjusted for opening at any instant, or for opening at the joint in the film. In the latter case, the shutter opens just after passing the joint in the film and closes just before reaching it. This mechanism is used when the time of the occurrence of the phenomena under consideration can be governed. When this cannot be controlled by the operator, the shutter is arranged to open at any instant and close after one complete revolution without regard to the joint in the film.

For viewing recurring waves, as has been stated, a so-called synchronous mirror is provided. This may be easily swung into position by a lever, without removing the photographic recording device. The synchronous vibration of this mirror, which is oscillated by a cam driven by a synchronous electric motor, provides the necessary range of action along the axis of abscissas,

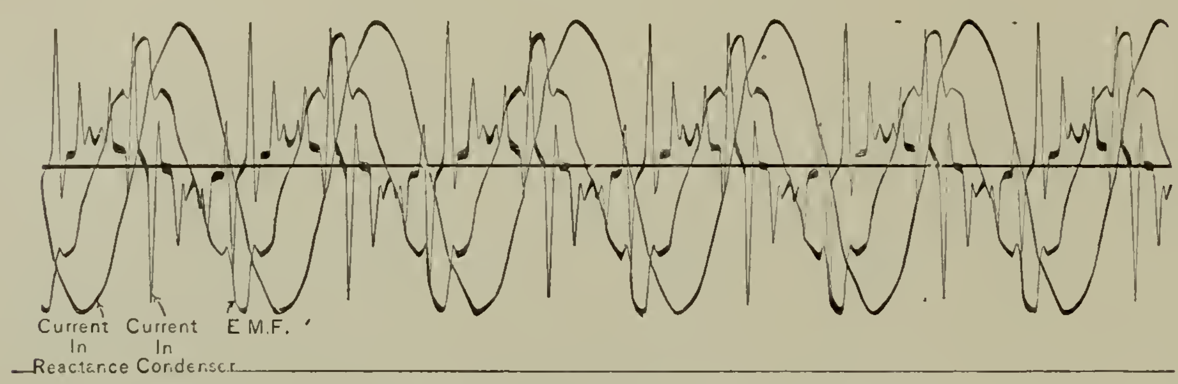


FIG. 5.—CURRENT AND ELECTROMOTIVE FORCE WAVES

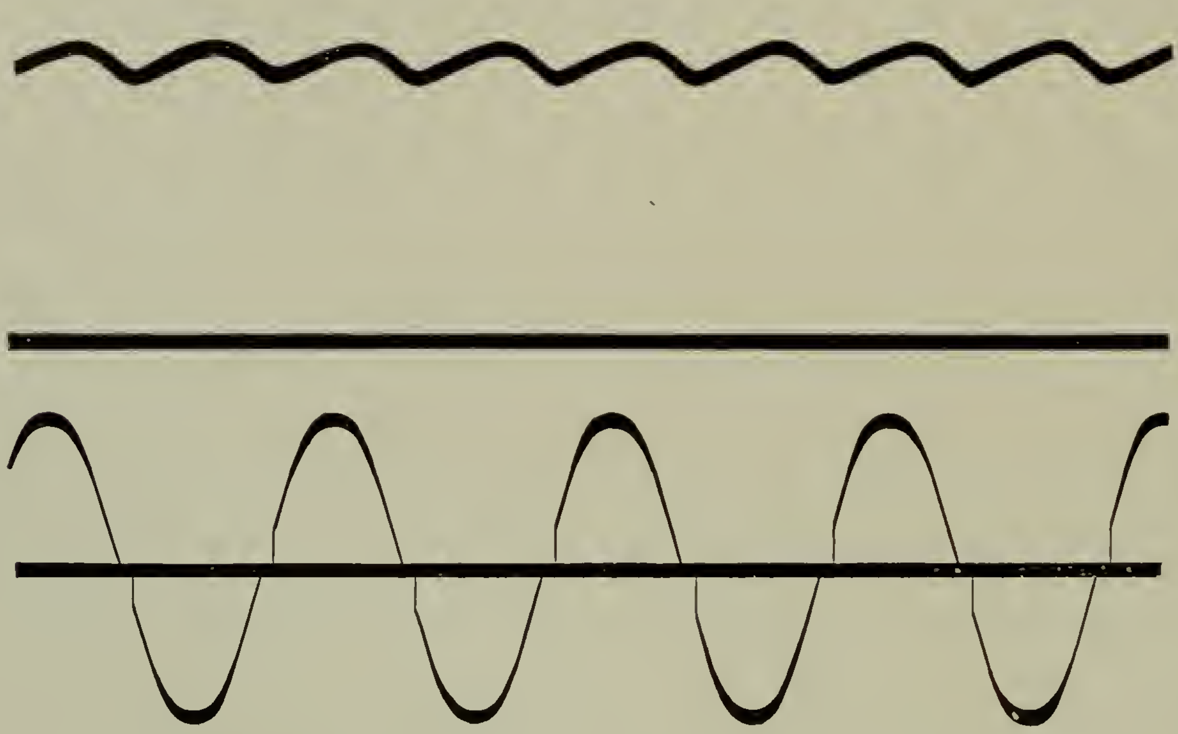


FIG. 6.—CURVES OF THE GENERAL ELECTRIC COMPANY'S MERCURY-ARC RECTIFIER. THE LOWER LINE SHOWS THE ALTERNATING-CURRENT SOURCE AND THE UPPER ONE THE RECTIFIED CURRENT

FIG. 7.—OSCILLOGRAM OF THE INDUCTIVE INCREASE IN VOLTAGE IN THE FIELD OF A SHUNT MOTOR ON OPENING A QUICK-BREAK SWITCH

and thus gives an image of the wave form.

The vibration of the mirrors having been adjusted so as to have a suitable amplitude, and the synchronous mirror being moved through a suitable angle during one complete cycle, the point of light on the screen will move through a path similar to that obtained when the wave is plotted to rectilinear coordinates. As the mirror returns to its original position, a shutter automatically cuts off the light and does not allow it to pass until the mirror again moves in the direction first indicated. This prevents admission of the light to the surface when the mirror is not moving in the proper direction.

Such an apparatus is useful in studying the action of the various phenomena in electric circuits having not more than 5000 or 6000 complete vibrations per second. The accompanying oscillograms show the application of the General Electric oscillograph to various phases of engineering in which this method of ascertaining hidden electrical conditions has been found highly valuable. Many of the large buyers of electrical apparatus make use of the oscillograph in conducting their investigations before deciding where their order shall be placed.

Westinghouse Electric Fans

FOR the season of 1906 the Westinghouse Electric & Manufacturing Co., of Pittsburg, Pa., present a largely increased assortment of electric fans. They are made for both direct and alternating-current service, and in forms known as the desk type, the bracket type, the ceiling type, the floor-column type and the counter type.

The desk and bracket fans are substantially designed, and the body and base present smooth surfaces, effectually preventing the accumulation of dirt, which so easily attaches to irregular outlines. They are finished in polished black enamel with guards and fans of buffed and lacquered brass.

The blades are a departure from the ordinary design formerly employed. They are constructed upon exact mathematical principles and their angles are theoretically correct, with the result, it is claimed, that the fan will give an even breeze across the entire front, as there is an absence of that tendency to project a hollow cone of air which is found in all fans whose blades have not been correctly designed. The breeze is sent out from the fan in the shape of a solid cylinder of air, and there is little tendency to set up eddy currents with their attendant losses. The determination of this correct blade angle has resulted in an extremely high air delivery, while the total watt consumption has been decreased, though the volume of air has been increased.

The fan blades are protected by a guard, secured in position by arms so rigid that the entire weight of the motor may be supported by the guard without injury.

The motor is mounted upon trunnions whose line of support passes through its centre of gravity. It is therefore balanced at any angle. There is, therefore, no tendency to turn over when the thumb is loosened, a point of great advantage. It is secured in any position by two thumb-screws; one holds it at any angle in a horizontal plane and the other at any angle in a vertical plane. All fan motors have, when running,

a tendency to shift from the position in which they are adjusted, but these clamping screws hold it secure when once adjustment has been made.

The fan motor consumes a very small amount of energy, it is claimed, the cost of running a 12-inch fan being three-quarters that of burning an ordinary 16-candle-power incandescent lamp on the same circuit, while a 16-inch fan can be operated at less than the cost of burning two such lamps.

By means of a simple adapter, the 12-inch and 16-inch desk and bracket types of Westinghouse fans are interchangeable. This provision makes it unnecessary for dealers to carry two types in stock, and also makes it possible for the user to attach the fan to the most convenient location without disconnecting lead wires, giving him all the advantages of the two styles of mounting.

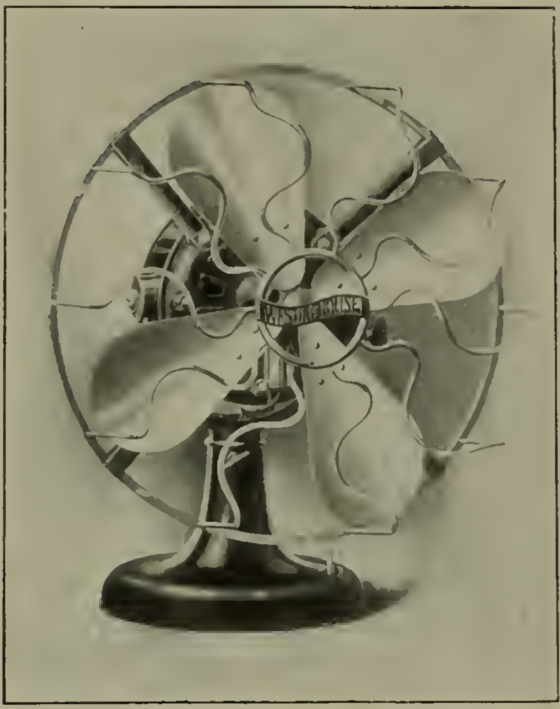
The motor used in the alternating-current desk and bracket fans is of the induction type, with stationary primary and rotating secondary. The primary is wound for either 110 or 220 volts, and for 7200 or 16,000 alternations per minute. The 7200-alternation motor is made with two bearings, which are of ample dimensions and automatically lubricated. In the 16,000-alternation motor, the shaft carries the fan at one end, and the secondary of the motor at the other, the two parts nicely balancing each other on one bearing.

The switch employed is of simple design and substantial construction. It is made of moulded insulating material of such form that it cannot easily be damaged or thrown out of alignment. The handle projects through a slot in the motor base at the most convenient and accessible point.

The start is made as readily when the switch is in the slow position as it does when in the high-speed position, so that there is no danger of burn-out because of failure and sudden restoration of power when the switch is set on the slow-speed contact. These excellent starting qualities have been secured by careful design of the motor combined with the use of a centrifugal device which cuts out the starting winding as soon as the fan has obtained sufficient speed, and by means of which a large amount of energy is saved which would otherwise be wasted.

The 1906 alternating-current fans are arranged for operation at two speeds of approximately 1625 and 1300 revolutions per minute. The slow speed is obtained by the insertion of a choke coil connected to the switch contacts and in series with the motor.

The field coils of the direct-current motor are machine wound, and the armature is of the drum type with slotted laminated core and carefully insulated winding. The commutator is so constructed and protected that wear is inappreciable. It is completely enclosed, but an easily removable dust shield makes inspection possible. The brushes are of carbon of the highest quality, and do not "chatter" or cut the commutator. The brush holders maintain an even pressure and perfect contact. The shaft is of the best hardened steel, and runs in bushings of fine bearing metal which give a long service, but can be easily renewed. There are



A NEW ALTERNATING-CURRENT DESK FAN MANUFACTURED BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG

two bearings provided with an automatic oil return which insures abundant lubrication as every point and prevents throwing of the oil.

Three different positions of the switch handle give three different operating speeds, with a maximum of 1650, a medium of 1300, and a minimum of 1000 revolutions per minute.

The ceiling and floor mountings have many distinctive features of great value. The cases are of graceful design and ornamental appearance, with a standard finish of black enamel and mottled copper, though other finishes may be furnished if desired.

The fan is made with four blades which are set at angles calculated to give the highest possible movement of air for the lowest possible consumption of energy. The blades are securely attached to the moving element by screws which effectually prevent them from turning from their normal position. The fans are designed for operation at three speeds, 200, 150 and 100 revolutions per minute, controlled by means of resistance wound about the bearing cup.

The switch is placed centrally in the under side of the fan body. As there are no live parts outside of the case, there is no danger of shock from handling or cleaning.

Fans of this type are made for operation from either 60-cycle alternating current, or direct-current circuits. The alternating-current motor is of the single-phase induction type with stationary primary and short-circuited secondary, which has no connection with the outside line. It therefore possesses no moving contacts or wearing parts except the bearings.

The direct-current motor is substantially constructed with rectangular field coils and a drum-type armature. The commutator is especially well made, embodying as it does all the high-grade features of other Westinghouse motors. The brushes are of the finest quality of carbon, and are so mounted that perfect contact and good commutation are maintained at all times. These motors are strong and reliable and are noiseless in operation.

The rotating element is supported upon noiseless ball bearings, which reduce friction to a minimum. A stationary shaft is provided with a spiral groove through which oil from the reservoir is forced upward by the rotation of the armature. Counter-type fans are exactly similar to those designed for floor-column mounting, with the exception that the shaft is made short.

Reinforced Concrete Telegraph and Telephone Poles

REINFORCED concrete poles for telegraph and telephone use were described in a recent issue of the "Canadian Electrical News." They were designed by J. L. Weller, superintending engineer of the Welland Canal, and are now used on the electrical transmission line of the canal.

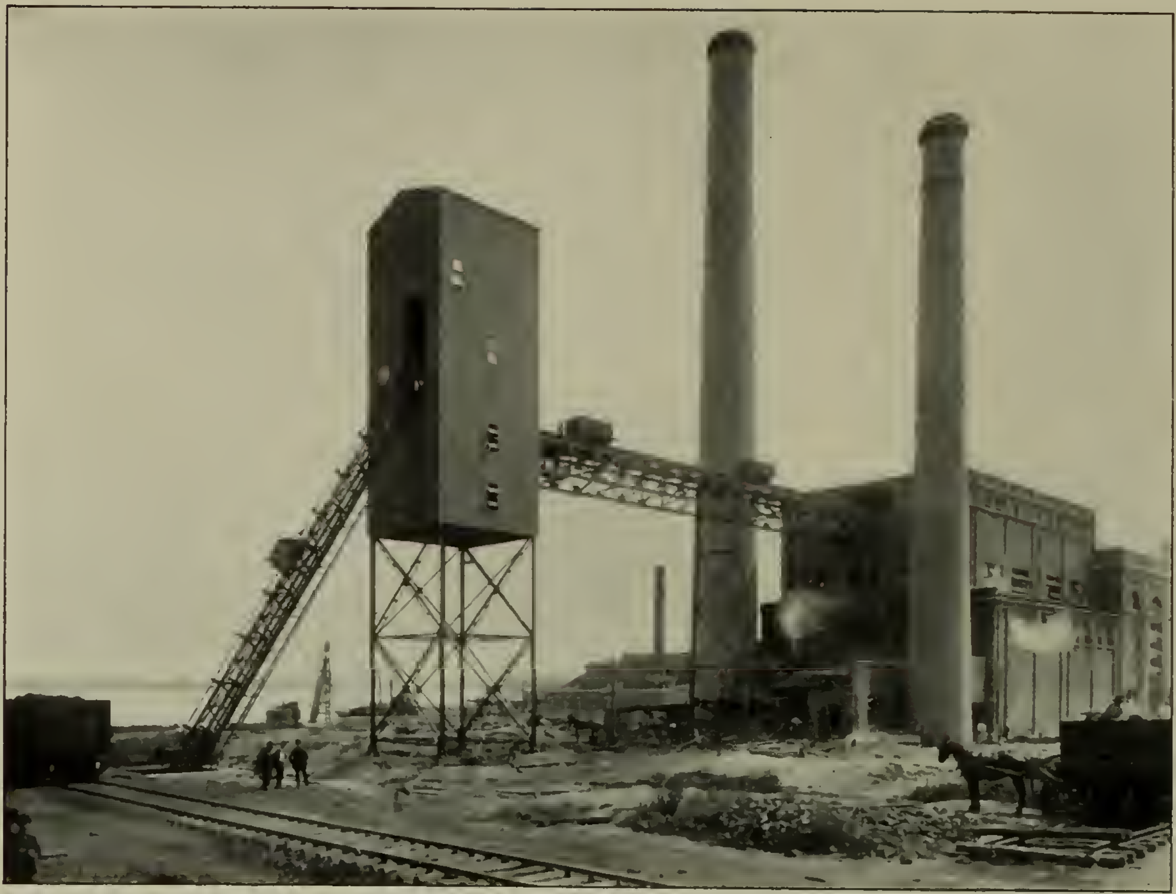
The poles are manufactured on the ground with their butts immediately over the hole in which they are to be erected. Wooden forms are used for moulding them in a horizontal position, the top being left open and finished with a trowel. Foot steps are imbedded in the soft concrete as the pole is being made, and bolts for cross-arms also, or holes are left so that a bolt may afterwards be put right through the

pole. The concrete is composed of a 1-2-4 mixture, using the best Portland cement, clean sand, and finely broken stone. Gravel has been used with success; in fact, most of the poles so far have been built with gravel instead of broken stone.

The patent rights for these poles are held in Canada by the Concrete Pole Company, Ltd., of St. Catharines, Ont., Mr. Weller being the president of the company. The United States patents are held by him personally.

A Recent Power House Installation of Coal and Ash-Handling Machinery

A RECENT installation by the Mead-Morrison Manufacturing Company, of New York, of coal and ash-handling machinery in the Gould Street station of the Maryland Telephone Company, of Baltimore, is shown in the annexed illustrations.



THE GOULD STREET STATION OF THE MARYLAND TELEPHONE COMPANY, BALTIMORE, EQUIPPED WITH COAL AND ASH-HANDLING MACHINERY INSTALLED BY THE MEAD-MORRISON MANUFACTURING COMPANY, NEW YORK

THE BOILER ROOM IN THE GOULD STREET STATION OF THE MARYLAND TELEPHONE COMPANY

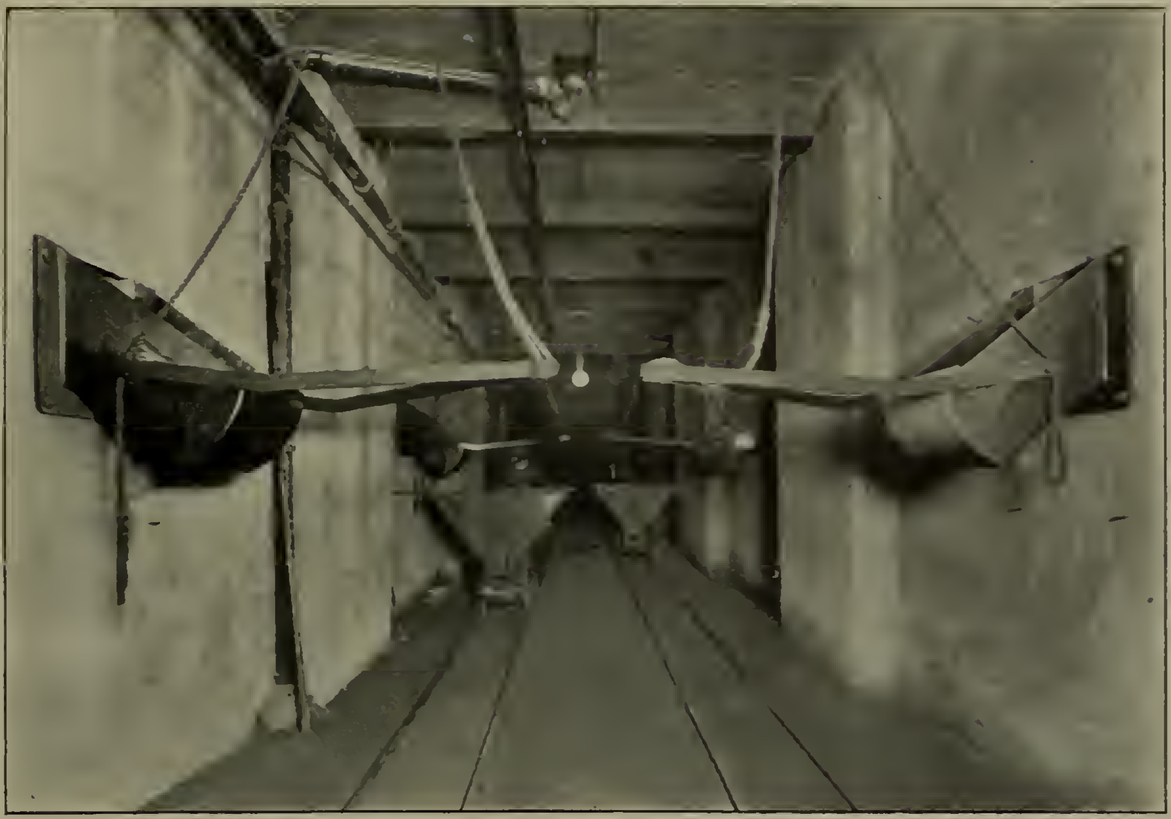
The coal is brought to the power house in railroad cars of the hopper-bottom type, and is dumped directly into a hopper beneath the tracks. From this hopper, the coal passes through a single-roll crusher driven by a direct-connected electric motor. A 2-ton hopper receives the coal from the crusher, and from this hopper the coal is hauled up an incline skip hoist.

The skip hoist is operated by a double-cylinder, single-drum steam engine, placed in the tower at the level of the cable-car tracks. The engine operator controls the loading of the skip by means of a valve on the hopper under the crusher. An electric light in the pit, close to the skip when in its lower portion, shows the operator when the skip is filled.

After the coal is elevated, it is dumped from the skip into a hopper, from which it is loaded into cable cars. These have eight wheels, are of 2-ton capacity, and are equipped with swivel grips. While being loaded, the cars stand on a platform scale, and the coal is weighed. One man loads the car, weighs it, and attaches the grip to the cable. From the tower, the car passes over the trestle to the power house, the cable making a single loop over the bunkers in the latter. The cars dump their loads at any desired point, and return to the tower without further attention.

Automatic side discharge permits the cars to be dumped by a tripping block set at any desired point. The cable driver is of the double-drum type driven by an electric motor, and is placed in the tower directly under the scale.

Swinging chutes feed the coal to the boilers from hoppers suspended in scales, so that the weight of each charge to the boilers can be determined. Beam boxes for the scales



THE ASH-HANDLING MACHINERY IN THE GOULD STREET STATION OF THE MARYLAND TELEPHONE COMPANY

are placed near the boiler room floor.

Directly under the boilers are concrete ash pits, from which the ashes are fed by valves to the tipping cars. These are run out by hand and the ashes used for filling in around the station. The capacity of the skip hoist is from 40 tons to 60 tons per hour. By adding more cars to the cable road, any increased capacity of the hoist is easily taken care of.

A Single-Phase Alternating-Current Railway for Milwaukee, Wis.

THE Milwaukee Electric Railway & Light Company, of Milwaukee, Wis., is about to equip two suburban extensions of its lines with the alternating-current apparatus manufactured by the General Electric Company, of Schenectady, N. Y. One of these lines will extend from Waukesha to Oconomowoc, a distance of twenty miles, and the second will operate between Hale's Corners and Mukwonago, a distance of sixteen miles. Both lines will be operated at a potential of 3300 volts, and in addition the motors are designed to run on the existing seven miles of 550-volt direct trolley line between West Allis and Milwaukee.

Each of the ten cars comprising the initial equipment for the road will be furnished with four standard single-phase motors of 75 horse-power each. These are of the compensated type, comprising an armature similar to the ordinary standard, direct-current, bar-wound form with mica-insulated coils. The motor fields consist of laminated pole pieces, over which are slipped the spools of the exciting winding; the compensating winding consists of a bar winding inserted in the pole faces and permanently connected in series with the armature winding. The 75 horse-power motor is wound for four poles and has a maximum speed of about 140 revolutions per minute.

These equipments will, in general, be operated as single cars, but occasionally will be run in two-car trains. For the flexible control of these train combinations the well-known Sprague-General Electric system of multiple unit control will be used, adapted for operation on alternating current.

The compensator for use in these cars is of the oil-cooled type, and is wound for 3300 volts on the primary, with five different secondary taps for controlling the speed of the motor. In order that the acceleration may be smooth, special devices are employed so that there will be no break in the circuit from one tap to the next during a change of speed. The speed regulation is so devised that the running speed will be the same on both the alternating and direct-current portions of the line.

Distribution of the various transformer substations on this line will be at 33,000 volts. At the stations the current will be fed to the trolley line at 3300 volts. For this latter the General Electric catenary construction will be used. It is proposed to have this line in operation during the fall of 1906.

Fusible Hanger Boards for Multiple Arc Lamps

FUSIBLE hanger boards, manufactured by the H. T. Paiste Co., of Philadelphia, for use with multiple arc lamps, are shown in the annexed illustrations.

The hanger boards are designed to receive either the ordinary 125-volt plug fuses or 250-volt cartridge fuses used with plug casings. Each block is provided with contact plates and set screws so that, by one combination, branch lines can be taken off and the lamp operated by individual side

FIG. 1.—FUSIBLE HANGER BOARD MADE BY THE H. T. PAISTE COMPANY, PHILADELPHIA, FOR CLEAT WIRING

FIG. 2.—THE PAISTE FUSIBLE HANGER BOARD FOR CONCEALED WIRING

FIG. 3.—THE PAISTE FUSIBLE HANGER BOARD FOR MOLDING WIRING

switches; or by different connections the lamp can be turned on and off from the main switch.

These branch lines can be wired in by open wiring, molding wiring, or by lamp cord and a pendant switch, and the work looks finished and neat when done by any one of the three methods. Large countersunk holes are provided for the screws that fasten the block to the ceiling, so that a good heavy screw can be used to easily carry the weight of the arc lamp.

Fig. 1 shows the type for cleat wiring. Here the main wires are carried right across the block, and contact is made by skinning the wires and slipping them under the clamp screw and washers.

For concealed wiring, the type shown in Fig. 2 is used. In this the wires are brought through from the back of the block and contact is made at the set screws on the face. Ample room is provided on the bottom to accommodate the ends of wiring-tubes necessary in this method of wiring.

Fig. 3 shows the type for molding wiring. This has, perhaps, more radical points of merit than either of the other styles. The easy wiring of the block is due entirely to the use of a contact button placed on top of the molding base. The main wires are skinned ¼ of an inch to set under the set screws of the contact pieces. The latter stick up at right angles to the button, and, when the hanger board front is set in place, go clear through it to the face and here make contact, by means of other set screws, for the fuses and lamp.

The running of the molding base can thus be done before any of the hanger boards are placed in position.

FIG. 4.—THE THREE DIFFERENT STYLES OF PAISTE HANGER BOARDS FOR MULTIPLE ARC LAMPS APPLIED TO THEIR RESPECTIVE METHODS OF WIRING

A New Stombaugh Guy Anchor

IN the August, 1905, number of The Electrical Age, particulars and illustrations were given of Stombaugh guy anchors manufactured by W. N. Matthews & Bro., of St. Louis, Mo. A new anchor, recently placed on the market, and embodying several improvements over the old style of 5 and 6-inch anchors, is shown on page 233. Anchors of these sizes are now made with square shanks of equal size, permitting the use of the same wrench for both; formerly separate wrenches were necessary.

In the past, considerable trouble was caused the users of 5 and 6-in Stombaugh guy anchors by defective welds in the rods and eyes; but this has been entirely eliminated in the new anchor, a full rod with no welds now being used. As the

METHOD OF PLACING THE NOW STOMBAUGH GUY ANCHOR MADE BY W. N. MATTHEWS & BRO., ST. LOUIS

eye is drop-forged and threaded, a much larger one is permissible, and standard guy thimbles may be used. The smooth finish and shape, however, do away with the absolute need of the thimble.

The wrench for the new anchor is simple, convenient and strong. Seamless, square tubing gives the hollow shaft a much greater torsional strength than the old-style round tube, it is claimed, and further reinforcing is had by brazing a malleable-iron square key on the lower end. The handles are attached to a sliding cross, held at any point on the shaft by a non-removable set-screw. The convenience of this arrangement is apparent, as the handles may be raised when too near the ground.

NEW STOMBAUGH GUY ANCHORS AND WRENCH MADE BY W. N. MATTHEWS & BRO.

In placing the anchor, the hollow shaft is slipped over the rod, after the eye on the latter is removed, and is firmly keyed to the square shank of the helix. The eye is then replaced on the rod, and serves to hold the wrench firmly in place during the operation. At a convenient point on the shaft the handles are placed, and the anchor is screwed in until the handles get too close to the ground. Loosening the set-screw then allows the handles to be raised to a more convenient position.

After the anchor is at the required depth, the eye is unscrewed, the wrench pulled off, and the eye replaced. The guy strand is then attached, the whole operation taking from 15 to 20 minutes.

The World's Copper Trade in 1905

THE world now consumes considerably more copper in a single week, according to H. T. Stevens in "The Mining and Scientific Press," than was required for an entire year a century ago. Despite the popular impression that the bulk of the copper production is required for electrical uses, the demands of the engineering trades still require more than half of the entire output of the metal. The minor uses of copper are very numerous, and are steadily increasing. Sulphate of copper, used as a spray on grape vines and currant bushes, as an insecticide, takes tens of thousands of tons of metal yearly. There is a single concern in the Naugatuck Valley, of Connecticut, that requires ten tons monthly for watch dials. The orders of the pin makers take vast quantities yearly, and such apparently insignificant things as brass balls for men's shoes require hundreds of tons annually. Modern buildings, both for residential and business purposes, are heavy consumers of copper, mainly in the form of brass for plumbing, gas and electric lighting fixtures, door butts and locks. Copper roofing requires large amounts of metal, and copper cornices consume materially larger quantities. While the bulk of the copper produced is required for the necessities of the engineering and electrical industries, no small amount is consumed for the little things, to which few but the close observers of the trade give attention.

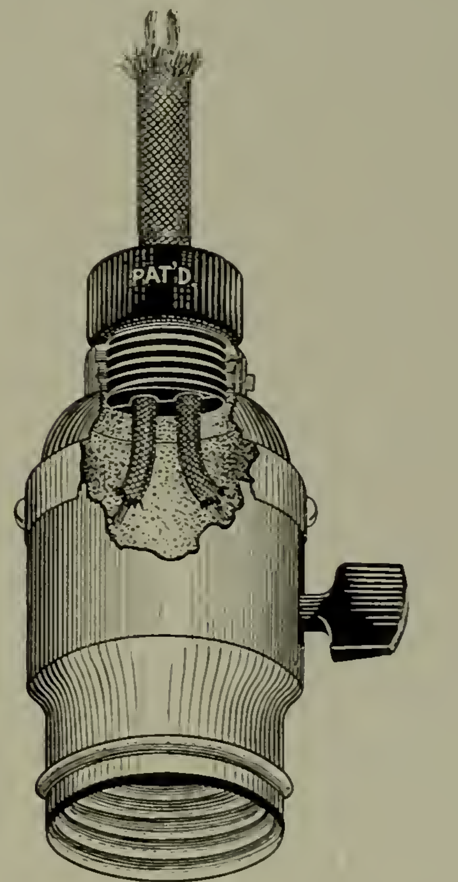
The year 1905 has given much the largest production of copper ever known, amounting to 723,550 tons, as against 648,924 tons in 1904. During the decade ending 1905, the production of the United States has increased 148 per cent., reaching 421,000 tons in 1905, and the production of all other regions 84 per cent. During the same period, Canada's production has increased 425 per cent., and Mexico's, 459 per cent.

A glance at the various copper producing countries of the globe shows that the most important developments have taken place in the United States. The Lake Superior district has several new producers; Montana shows a large gain in production, and Arizona has made a phenomenal increase during the year.

Strain Bushings for Lamp Connections

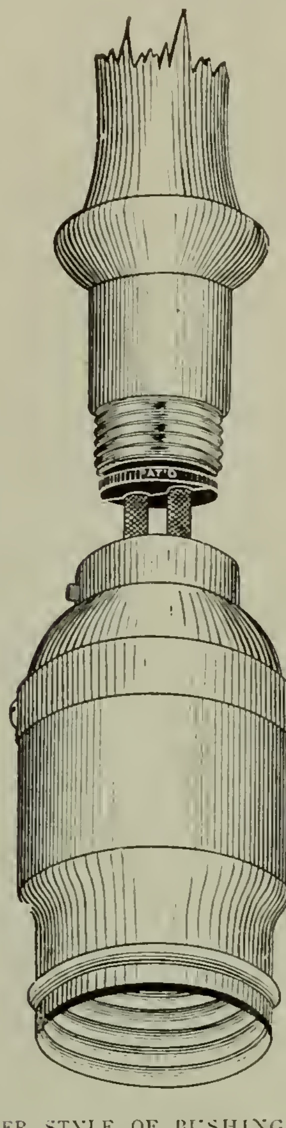
BUSHINGS manufactured by the Frank H. Stewart Electric Co., of Philadelphia, Pa., for taking the strain off electrical connections in $\frac{3}{8}$-inch sockets and ceiling rosettes, are shown in the annexed illustrations. The bushings for ceiling rosettes can also be used as a handle bushing, as shown in the larger illustration.

"Knostrain" bushings, as they are called, are made in two pieces with corrugated grooves to grip the lamp



A BUSHING MANUFACTURED BY THE FRANK H. STEWART ELECTRIC COMPANY, OF PHILADELPHIA, FOR TAKING THE STRAIN OFF LAMP CORDS

or show-window cord, and also act as an insulator. The company anticipate a considerable demand for



ANOTHER STYLE OF BUSHING FOR USE WITH CEILING ROSETTES OR AS A HANDLE

these bushings, as the Fire Underwriters recommend a device for doing away with the knotting of cords as now practiced.

Samples of these bushings will be sent on request to the company.

Trade News

The Allis-Chalmers Co., of Milwaukee, Wis., has recently received an order from the Pabst Brewing Co., of the same city, for additional steam and electrical units. There are three engines in all,—one of the single-cylinder, non-condensing type, cylinders 20 inches by 36 inches, and two of the cross-compound, non-condensing type, 18 inches and 30 inches by 36 inches, all vertical and of the heavy duty pattern for direct connection to electrical machines. The electrical equipment will consist of three revolving-field, 25-cycle, alternating-current generators, one for 300-KW. and two for 400-KW. capacity; two exciter sets consisting of direct-current, constant-potential, compound-wound generators, coupled direct to three-phase synchronous motors and fitted with starting motors of the induction type; and one exciter set consisting of a direct-current generator of the same type as described, but arranged for steam drive. A feature of the new installation will be in a special governing device, consisting of an electrical adjusting or synchronizing attachment by which the speed of the engines may be varied within certain limits while they are in operation, the device being under control of the operator at the switchboard. It is expected that the first of the new units will be in operation by the first of May. Other orders received by the Allis-Chalmers Co. are as follows:—One 425-KW. generator unit for the Zunkenheimer Co., of Cincinnati, Ohio; two additional generators for the Crystal City, Mo., plant of the Pittsburg Plate Glass Co.; a 100-H. P. motor in addition to the alternators and motors now being installed for the Watab Pulp & Paper Co., Sank Rapids, Minn.; an addition to the present power plant of the American Car & Foundry Co., at Huntington, W. Va.; a 20 by 36-inch Reynolds-Corliss engine for John C. Cummings, Paris, Ill.; a 16 by 30-inch Reynolds-Corliss engine for the Gilbert Paper Co., Menasha, Wis.

J. P. Devine, of Buffalo, has organized the J. P. Devine Company, to manufacture the Passburg vacuum drying and impregnating apparatus. W. Strohm, for twenty years a member of the firm of Emil Passburg, of Berlin, Germany, is now vice-president of the J. P. Devine Company. The company will also be assisted and advised by the German firm, which has made over its entire American interests to the J. P. Devine Company.

Among the first steam turbines built by the Allis-Chalmers Company, of Milwaukee, Wis., to be installed in the Southern States are those of two 500-KW., 3-phase, 60-cycle, 2300-volt units ordered by the city of Jacksonville, Fla., to supplement a 500-KW. unit installed over a year ago. Another new electrical equipment for Florida is that for the St. John's Light & Power Company, of St. Augustine, who have recently ordered additional engine-generator units, with exciters, switchboard and accessories, as follows:—One 325-KW. alternator, direct-coupled to an 18 and 36 by 30-inch cross-compound, "Reliance" Corliss engine; a 250-KW. alternator, direct-connected to an 18 by 30-inch "Reliance" Corliss engine; a 100-KW. railway type generator, direct-connected to a 12 by 24-inch "Reliance" Corliss engine; and a 90-KW. motor-generator set and complete switchboard.

The Quincy, Manchester, Sargent Company, of Chicago, has been incorporated, and will take over the business and plant of the Railway Appliances Company at Chicago Heights, Ill., formerly owned by the Q. & C. Company, also the business and plant of the Pedrick & Ayer Company, of Plainfield, N. J., manufacturers of locomotive repair tools, electric and pneumatic hoists and cranes, and pneumatic riveters. The Quincy, Manchester, Sargent Company will also act as sole selling agent for the product of the Elastic Nut & Bolt Company, of Milwaukee, Wis.

Messrs. Dodge & Day have removed to their new offices, located in the Drexel Building, Philadelphia, in order to be nearer to the financial center, as well as to obtain more commodious quarters. This step is the natural result of the rapid growth of their business.

Announcement is made that the Rawson & Morrison Manufacturing Co. have consolidated their business with that of the Mead-Morrison Manufacturing Co., of New York, and hereafter the business will be conducted under the name of the latter company. The change of name is the only one that will be made, as the Mead-Morrison Manufacturing Co. will continue to manufacture the same lines of hoisting engines, derrick swingers, electric hoists, belt hoists, suspension cableways, as well as cable roads and all kinds of machinery for handling coal and other bulky materials.

The largest order ever placed for oil engines has recently been awarded to the De La Vergne Machine Co., of New York, by Burnham, Williams & Co., (Baldwin Locomotive Works) Philadelphia, Pa. This is for engines aggregating over 3300 actual H. P. Some of these are to be installed in Philadelphia, and the remainder at their steel works, at Burnham, Pa. The installation will consist of 125 and 250 H. P. "Hornsby-Akroyd" oil engines and they are to be used for direct connection to electric generators and to air compressors, while others will be used for operating machine tools by belt. The "Hornsby-Akroyd" oil engine is too well known to need any further reference to it here, but the remarkable economy effected by the use of this engine can be understood when it is stated, that with crude or fuel oil at 2 cents a gallon, the

cost of operation is ¼ cent per actual H. P. per hour. The De La Vergne Machine Co. now holds the enviable record of having sold the largest gas engine power plant, the largest ice plant and the largest oil-engine power plant in the world.

In the new power house of the Interborough Rapid Transit Company, New York City, the 26,000 horsepower boilers now installed are soon to be equipped with economizers built by the B. F. Sturtevant Company, of Boston, Mass. The twenty-eight economizers will contain 7840 pipes, having an aggregate length of nearly fifteen miles. They will increase the heating surface of the plant about 25 per cent. and store 265 tons of hot water, or 18 per cent. of the volumetric capacity of the boilers. It is estimated that the saving due to the utilization of heat in the waste gases will average more than 10 per cent. for the whole twenty-four hours. This figure will be greatly exceeded while the load is at a maximum, at which time the heat will be utilized which was previously stored while the fires were banked. The remarkable efficiency is due largely to the staggered arrangement of the economizer pipes, which break up the currents of hot gases and cause them to deliver the maximum amount of heat to the water.

The Frevert Machinery Company have opened a salesroom and office at 18 Dey street, New York, with a complete line of new and second-hand metal-working tools and machinery. Hand-power travelling cranes, trolleys, hoists, and overhead tracks are also manufactured by them.

Dossert & Co., of New York, manufacturers of connections for electric wires, gas and water pipes, have moved to their new factory and offices at 242 West Forty-first street, where they have facilities for a largely increased production.

Generating sets are now manufactured by the B. F. Sturtevant Company, Boston, Mass., in a line of thirty-six sizes, ranging from 3 to 100 KW., direct connected. The vertical cross-compound engines were designed to meet the rigid specifications of the United States Navy Department, which in the case of the 100 KW., demand an efficiency of 31 pounds per KW.-hour. These engines, as well as the vertical and horizontal simple engines, are entirely enclosed, provided with forced lubrication and watershed partitions. The generators are multi-polar, capable of carrying 50 per cent. momentary overload and 25 per cent. excess for two hours without sparking or undue heating. The smaller sizes of these sets are particularly adapted to service as boosters.

The Westinghouse Machine Company, of Pittsburg, have opened a Philadelphia sales office in Room 1003, North American building. The establishment of this office was necessitated by their rapidly expanding business in this territory, particularly in gas engines and Westinghouse-Parsons steam turbines, and it is in line with the progressive policy of the company to establish headquarters in all large industrial cities.

The Electric Cable Company, of 42 Broadway, New York, have received an order from the New York & Long Island Railroad Company for fifteen miles of cable insulated with Voltax, the new high-potential insulating compound. This order followed within a week upon that of the Interborough Rapid Transit Company, who recently ordered from the same company the same amount of material. The good results which have been obtained from this compound after severe tests are giving this material prominence with the railroad companies, with which Voltax is becoming extensively used. The material is claimed to retain its elasticity and insulating properties for an indefinite period, to be impervious to atmospheric conditions and water, acid and alkali-proof. Recent tests by the Electrical Testing Laboratories, of New York, show that the Voltax compound will not drip under 200 degrees F. The same company has recently received an order from the Bullock electrical works of the Allis-Chalmers Company, at Cincinnati, Ohio, for the new insulating compound "Voltax," for impregnating field and armature coils. The tests which were recently made of this compound by the Electrical Testing Laboratories, of New York, showed, it is claimed, that Voltax possesses all of the insulating properties of rubber, and in many cases has withstood tests far more severe than rubber. As Voltax has no injurious effects upon copper, it does not require tinning before applying the compound, as there is no corrosive action whatever. It is claimed that it is not subject to chemical change, and that it withstands a voltage test 100 per cent. greater than a rubber insulation. These tests have also proved that Voltax wire and cables can be handled at all temperatures, and the insulation will not crack or harden at 20 degrees F.

The Abner Doble Company, of San Francisco, has recently taken a contract for a Doble tangential water wheel unit which will have a capacity of 13,000 horse-power, thus surpassing in power any tangential wheel now built or contracted for. The unit has been ordered by the California Gas & Electric Corporation, for installation in its noted Colgate plant, where it will form a valuable addition to that company's extensive hydro-electric system. It will be of the double-wheel, two-bearing type of construction, and when first installed will operate under an effective head of 660 feet, delivering 8500 horse-power. It is planned eventually to increase the pressure on one of the wheels by delivering the water through a new pipe line under an effective head of 1050 feet. This will bring the output of the unit up to 13,000 horse-power, and make it the most powerful tangential hydro-electric unit in existence. The unit will operate at a speed of 300 R. P. M., and will drive a 5500-KW. Westinghouse generator. It will be equipped with a Bethlehem nickel-steel hollow forged shaft, and Doble ring-oiling, revolvable-shell bearings, needle regulating and deflecting nozzles, ellipsoidal buckets, and centrifugal water guards. The California Gas & Electric Corporation has also ordered from the Abner Doble Company a Bethlehem nickel-steel hollow-forged shaft, with two 16-inch Doble ring-oiling and revolvable-shell bearings, for its Centerville plant. The bearings will be equipped with the latest sight-feed oil-distributing system.

New Catalogues

A lesson in wire-rope splicing is given in an attractive pamphlet sent out by the John A. Roebling's Sons Company, of Trenton, N. J. It is similar to one previously issued, except that in the old edition a ¾-inch rope was dealt with, while in the present instance the size is 1 inch. The new illustrations also show the various steps more clearly. Some of the Roebling products are illustrated in another, smaller, pamphlet. The old Brooklyn Bridge and the new Williamsburg Bridge, connecting the New York City boroughs of Brooklyn and Manhattan, head the list, and some of the various uses of wire rope are shown. Wire rope fastenings, alligator wrenches, steel-case

bell cord, galvanized telephone wire, copper telephone wire, and insulated electrical wires and cables complete the list.

Fans for alternating current are described in a catalogue recently sent out by the Emerson Electric Manufacturing Company, of St. Louis. The motors are of the induction type, the coils for starting being automatically disconnected from the circuit when the fan reaches the proper speed.

A new pamphlet, dealing with the general line of coal-handling and like machinery, built by the C. W. Hunt Company, of West New Brighton, Staten Island, N. Y., contains essentially the same matter given in a pamphlet sent out a few months ago, and noticed in these pages. A change, however, has been made in the illustrations, and the matter re-arranged. In brief, the machinery built by the company includes staple and parabolic boom towers, elevators, steam shovels, coal crackers, tubs, blocks and sheaves, transmission rope, industrial railways, steam and electric hoisting engines, conveyors, overhead trolleys, coal screens and valves, scales, and electric locomotives.

A catalogue dealing with the applications of electricity to mining was recently sent out by the Jeffrey Manufacturing Co., of Columbus, Ohio. The text is by F. L. Sessions, and the illustrations show everything from the generating plant to the motor-driven tool. Electric locomotives, coal-cutting machines, drills, pumps, hoists, generators and switchboards are included in the list.

The Crocker-Wheeler Company, of Ampere, N. J., are sending out a bulletin listing the company's direct-current, engine-type generators which are now in use or have been ordered. The number of installations is nearly 700, and the sizes range from 1050 KW. to 25 KW.

Two attractive pamphlets, one devoted to the lighting of churches, schools, libraries, and hospitals, and the other to the lighting of theatres and public halls, were recently sent out by the Holophane Glass Company, of New York. A number of excellent illustrations show the lighting of these buildings by electric lamps fitted with Holophane globes. The problems dealt with in each case are outlined, and the manner in which they were solved is explained. Both pamphlets are examples of creditable typographical work.

"Bullock" direct-current railway generators are illustrated and described in a bulletin recently issued by the Allis-Chalmers Company, of Milwaukee, Wis. They are built in three types, two for belt drive and one for direct connection. The latter is fitted with a device for moving the brushes back and forth across the commutator to prevent the wearing of grooves. Besides illustrations of parts of the generators, views of installations are given.

A pamphlet recently sent out by the Abner Doble Company, of San Francisco, contains a reprint of a paper on "The Irrigation System of Ontario, California — Its Development and Cost," read by F. E. Trask before the American Society of Civil Engineers. The paper deals with the development and present status of an irrigation plant in the "Orange Belt" of Southern California. The power plants for supplying current for the electric pumps are provided with Doble wheels.

Oil switches and circuit breakers manufactured by the Hartman Circuit Breaker Company, of Mansfield, Ohio, are illustrated and described in a bulletin recently issued. The apparatus described has been added to the company's line of products since the publication of a former bulletin. A 3-pole oil switch is shown, for either switchboard or wall mounting, and for potentials not exceeding 6600 volts. Another type is for potentials not exceeding 3300 volts, and is made in both single-throw and double-throw form. An automatic circuit breaker for potentials not exceeding 6600 is also illustrated, as is the company's remote system of control for oil switches and circuit breakers.

"Gas Power in Electric Railway Work" is the title of a pamphlet recently sent out by the Westinghouse Machine Company, of Pittsburg, Pa. It contains reprints of two papers presented before the American Street and Interurban Railway Association at the Philadelphia convention in September, 1905. The first paper is entitled "Notes on the Design of Large Gas Engines, with Special Reference to Railway Work," by Arthur West, chief engineer of the company, and the other is on "The Application of Gas Power to Electric Railway Work," by J. R. Bibbins, also of the company. Another pamphlet contains a reprint from the March, 1904, number of "Cassier's Magazine," on "Gas Power for High-Pressure City Fire Service," also by Mr. Bibbins.

A bulletin recently sent out by the H. T. Paiste Company, of Philadelphia, illustrates and describes fusible hanger boards for multiple arc lamps, taplets for making branch moulding circuits, two-wire and three-wire panel cut-outs, entrance switches, and rosette receptacles. An illustrated description of the fusible hanger boards is given elsewhere in these pages.

"Under the Gates of Babylon" is the title of a unique folder sent out by E. T. Smith & Co., of Cleveland, Ohio, manufacturers of "Buckeye" incandescent lamps. The illustration represents the fall of Babylon and the text recites the events of the fatal night, translating the memorable handwriting on the wall into the modern adjuration, "Better Buy Buckeye."

Bulletins recently sent out by the General Electric Company, of Schenectady, N. Y., deal with arc lighting apparatus, variable-speed motors, and type "R" switchboard instruments. Other literature is devoted to a seamless outlet box for flush pocket switches and wall receptacles, ceiling rosettes, speed-controlling rheostats for use with variable-speed, shunt or compound-wound motors, household electric devices, sleet cutters, and fan motors. Very acceptable blotters also tell of the merits of railway line material and curve-drawing ammeters, voltmeters, and wattmeters.

How to use Mannheim and multiplex slide rules is told in a neat booklet sent out recently by the Eugene Dietzgen Company, of New York. The text is by L. W. Rosenthal, inventor of the multiplex slide rule. The various methods of using these most useful instruments are shown by examples, and the tables of conversion ratios given are of great convenience.

Wainwright feed-water heaters and expansion joints are illustrated and described in a catalogue recently sent out by the Alberger Condenser Co., of New York. The heaters are provided with corrugated copper tubes and made in vertical and horizontal types. Steam tube heaters, for use in the line of the exhaust main between the engine and its condenser, are illustrated and described, and heat extractors, for use with compressed air, oil, gas, steam and water, are also dealt with. Of the expansion joints, one type consists of a main corrugated tube of soft copper, an inner cylindrical slip tube of hard copper or composition, ex-

ternal and internal equalizing rings of cast iron, and connecting flanges of cast iron or steel. The other type, for use in connecting piping between turbines and condensers, consists merely of the corrugated tube with flanges.

Industrial, narrow-gauge and standard-gauge railway equipment is illustrated and described in a catalogue recently issued by the Arthur Koppel Co., of New York. Rails, ties, switches, crossings, and turntables are among the things listed, and a variety of cars are also illustrated, together with coal buckets, scales, locomotives, and concrete mixers.

A very attractive catalogue is that recently sent out by the Holophane Glass Co., of New York. It is well bound in leather, and is arranged for the insertion of additional pages. The many varieties of the company's globes and reflectors are illustrated and described, and curves showing the results of tests at the Electrical Testing Laboratories are also given. The booklet is rather out of the ordinary run of catalogues and is a commendable piece of work.

Steel racks for use in stock rooms are illustrated on a card sent out by the Lyon Metallic Manufacturing Co., of Chicago, Ill. Steel factory equipment is now well recognized as reducing the fire risk and adding greatly to the cleanliness and smart appearance of the up-to-date shop. The company also announce that they have a jobbing department equipped for all kinds of sheet metal, copper, tin, and galvanized iron work.

Auxiliary-pole motors built by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa., are described in a bulletin recently issued. They are of the now well-known type with auxiliary poles between the main pole-pieces, the auxiliary winding being in series with the armature. The field of application for these motors is machine-tool work requiring variable speed. With a single line voltage, speed variation is obtained by field control.

Personal

L. B. Stillwell has been appointed electrical director in charge of the various Belmont properties in and near New York City. These include the Interborough Rapid Transit Railway, Section No. 1, which is the subway down to the City Hall; the Interborough Rapid Transit Railway, Section No. 2, the section from the City Hall to Brooklyn; the Manhattan Elevated Railway; the New York & Queens County Railway, of Long Island City; the New York City-Interborough Railway, of the Bronx; the New York & Long Island Railroad, popularly known as the "Steinway Tunnel"; the Long Island Electric Railway Company, which owns an electric railway between Brooklyn, Jamaica and Far Rockaway; the New York & Long Island Traction Company, which owns an electric railway between Mineola, Hempstead and Freeport, and the City Island Railway, which is at present operated by horses.


J. A. MILNE

James A. Milne, who for a number of years has been comptroller of the Allis - Chalmers Company of Milwaukee, Wis., has accepted the position of general manager of Allis-Chalmers - Bullock, Ltd., Montreal, Canada, to become effective on or about May 1, 1906. Mr. Milne is a native of Canada, having been born at Watertown, Ont., in 1872. After completing a public school and collegiate course, he began his business career at Toronto, in 1888. In August, 1901, he entered the employ, as chief cost clerk, and one month later was appointed acting comptroller, of the Allis-Chalmers Company, being formally elected to that position in May, 1902. Since the early part of last autumn he has been one of the directors of Allis-Chalmers-Bullock, Ltd., and the fact that he still retains Canadian citizenship, and is deeply attached to his early associations, has been an important factor in influencing him to heed a recall to the Dominion. His successor as comptroller of the Allis-Chalmers Company will be L. F. Bower, heretofore manager of the company's electrical works at Cincinnati. Mr. Bower graduated from Wesleyan University in 1879. For some years previous to 1901 he was secretary and treasurer of the Dickson Manufacturing Company, of Scranton, Pa.—then absorbed by this company,—and on April 1, 1904, he was transferred to the electrical department at Cincinnati.

An electrical commission has been appointed by the Erie Railroad to consider in detail the electrification of the company's suburban lines. The commission consists of J. M. Graham, vice-president of the company, and chairman of the commission; Bion J. Arnold, L. B. Stillwell, E. A. Williams, general mechanical superintendent; A. J. Stone, assistant general manager; C. H. Morrison, acting electrical engineer and secretary of the commission.

In pursuance of a resolve made many years ago to retire from active business at his present age, E. H. Valentine, president of the Valentine-Clark Co., of Chicago, Ill., dealers in cedar poles, has disposed of his interests in that company to E. L. Clark, formerly secretary and treasurer, who now succeeds him as president, the corporate name of the company continuing as heretofore. The Valentine-Clark Co. has long occupied a commanding position in the cedar industry and enjoys an extensive volume of business in all lines of electric construction requiring poles for power transmission. Mr. Clark has been identified with the above mentioned company since its formation, enjoys an extensive acquaintance with producers and consumers, and possesses an intimate knowledge of the trade in all its details.

Arthur Giesler, until recently chief engineer of the Platt Iron Works Company, of Dayton, Ohio, has opened an office at 170 Broadway, New York. He will devote himself to the designing of water-power plants and pumping stations.

William T. Dean, for the past four years chief electrician for the Illinois Steel Company, of South Chicago, Ill., has resigned, to enter the service of the General Electric Company. He will devote his time to the iron and steel industry in the Chicago district.

Paul N. Nunn, chief engineer of the Ontario Power Company, has spent the past few weeks on a trip to the Orient. Mrs. Nunn accompanied him. Mr. Nunn stopped at the principal Mediterranean ports of interest, going as far as Alexandria, in Egypt, and Jaffa, in Palestine.

George Gibbs, chief engineer of electric traction for the New York City terminal of the Pennsylvania Railroad, has just assumed, in addition to his many other duties, the electrification of 125 miles of track of the Atlantic City division of the Pennsylvania Railroad.

Alex. Dow, vice-president of the Detroit Edison Electric Illuminating Company, has gone abroad for sev-

eral months' vacation. He will spend the time principally in England.

Obituary

In the recent death of Samuel Pierpont Langley, secretary of the Smithsonian Institution, at Washington, D. C., the scientific world suffered a great loss. Up to the thirtieth year of his life, after an education at the Boston High School, he practised civil engineering and architecture, devoting himself privately to the study of astronomy. In 1865 he became an assistant at the Harvard College Observatory; in 1866, assistant professor in mathematics at the United States Naval Academy, at Annapolis, and at the end of that year, director of the Allegheny Observatory, at Pittsburg. While here he inaugurated the system of supplying standard time by telegraph. From 1869 he had charge of several of the expeditions sent out by the government to study solar eclipses. His astronomical work had been devoted almost exclusively to the study of the sun, for which he had invented numerous new devices, notably the bolometer, a most delicate instrument for measuring heat. From boyhood he was interested in aerial flight. This subject he took up seriously in 1889, and in 1891 published his "Experiments in Aerodynamics," followed in 1893 by the "Internal Work of the Wind." He was also the inventor of the Langley flying machine. In 1887 he became secretary of the Smithsonian Institution, at Washington, D. C., which has under its charge various agencies of widely diversified scientific interests. His published writings include over one hundred titles. In addition to many technical papers and works of value, he wrote "The New Astronomy," and delivered several notable addresses. He was a member of many scientific bodies both here and abroad, and received the degree of D.C.L. from Oxford, D.Sc. from Cambridge, and, among numerous others, the degrees of LL.D. from the universities of Harvard, Yale, Princeton, Michigan, and Wisconsin.

SAMUEL PIERPONT LANGLEY

An Austrian High-Tension Direct-Current Railway

At a recent meeting of the Austrian Society of Engineers and Architects, Franz Krizik described his system of high-tension, direct-current traction now being tested on the Vienna railway. This road is to be worked with electric locomotives fed with current by three overhead wires, the voltage between the outside wires being 300 volts.

The locomotives have two axles, each being driven by two 200-H. P. motors, the pinions of which engage with a common gear wheel keyed to the axle. In order to obtain satisfactory commutation, the flux-density in the armature has been kept high, a large number of commutator segments has been adopted, and one turn per segment is employed.

At starting, all the four motors of the locomotive are connected in series across one side of the three-wire supply; as soon as the motors are fully accelerated they are connected in series across the outer wires. If a still higher speed is desired, it is obtained by weakening the motor fields.

A 9700-H. P. Hydraulic Turbine

An interesting point in connection with the recent purchase by the California Gas & Electric Corporation, San Francisco, of a 9700-H. P., single horizontal, spiral case, reaction hydraulic turbine, is found in the fact that this turbine will operate under a 550-foot head at a speed of 400 revolutions per minute. This is probably the highest head under which a turbine of this type has ever been installed. Until recently, manufacturers of secondary machinery have avoided the operation of their apparatus on high speeds. This prejudice, however, has, to a great extent, been overcome and it is only a question of time when this type of hydraulic turbine will be constructed for still higher heads than the present practice will allow. This turbine and accessories will be furnished by the Allis-Chalmers Co., of Milwaukee, and is destined for installation at Chico, Cal.

In Denmark there are 17 telephones to each 1000 inhabitants, the corresponding number in Sweden and Norway being, respectively, 19 and 16.

Electricity in the Research Laboratory

By J. L. BRONSON

THE practical usefulness and flexibility of electricity are nowhere better illustrated than in the research laboratory. In view of the fact that many important electrical inventions and processes owe their origin to laboratory investigations, it is not astonishing that in both industrial and purely scientific researches electrical methods are constantly being developed to meet the needs of the modern experimentalist.

Until one visits the research departments of industrial organizations, colleges, and governmental bureaus, the variety of useful applications of electricity in these fields is little realized. These convenient contrivances are more creditable on the score of their labour-saving qualities than on the grounds of novelty, but they are none the less interesting on that account.

Time in the laboratory is of far more value than many investigators realize. The results of any given scientific research may be impossible of prediction, or they may be definitely anticipated; in the one case it is well to determine the limitations promptly in order that new angles of attack may be selected without undue expense; and in the other case the sooner the results are known, the better, for then the investigations can be more quickly turned to practical account and fresh experiments or broader researches planned.

In general, ample light of good quality is a prime requisite for the performance of first-class laboratory work. Gas is a useful commodity in all physical and chemical laboratories, but its proper use is for heating, rather than for illumination. The Bunsen burner is an important appliance in many experiments requiring the application of intense heat at a localized area, and it will doubtless be a long time before it will be entirely superseded by any other equivalent device. The plain fish-tail burner is of the utmost value in glass blowing and bending, but its vitiation of the atmosphere should bar it from being utilized for illuminating purposes if electricity is available.

The Bunsen burner, however, is in many cases being superseded by electric heaters. In experiments with liquids giving rise to explosive vapours when boiled in test tubes or beakers, great care is often necessary to avoid catastrophes if an open-flame burner is used, and for this reason the electric stove has found much favour in modern laboratory installation. Even the long-tried steam bath has in some cases been driven from the field by its more cleanly, flexible, and economical rival, electricity.

These are days when little things count heavily in research work. A large part of the time required by every thorough experiment is necessarily given up to checking results and methods for the purpose of eliminating errors, or reducing them to a minimum. There can be no question that the laboratory which is lighted by electric incandescent lamps offers more favourable conditions for the performance of delicate chemical experiments than one in which the atmosphere is befouled by the combustion products of a gas flame. In certain kinds of analysis great care is necessary in order that the substances under treatment shall not be permitted to absorb impurities, and the presence of one or more gas flames is unquestionably a menace, in comparison with the absolutely clean illumination furnished by electricity.

The personal comfort of the investigator is also far greater in the electrically lighted laboratory, and in exhaustive researches the physical conditions surrounding the work count for much more than is ordinarily supposed. The fan motor is a great boon to the laboratory in warm weather, and in other seasons it is often valuable as an accelerator of evaporative processes. Photographic plates can often be dried within a few minutes of their development, in this way, and the employment of the fan motor to exhaust injurious fumes from the vicinity of those engaged in experimental work has been practiced successfully of late.

The small motor is a power for good in many varieties of laboratory work. In the development of apparatus for experimental uses there are many processes in which materials may be ground, cut, cleaned, and polished, and in such cases the small motor is literally invaluable as a time-saver. Compressed air from a small motor-driven outfit is used in many of the best modern laboratories, and in many experiments it is found useful to employ motor-driven pumps for both liquid and gas work.

The operation of coil-winding machines and small lathes by electric power, is naturally greatly superior to the old method of using foot power. Motor-driven commutators and contact makers are valuable appliances, and in physical work involving definite periods of time, special relays, batteries, and signal circuits are indispensable. The most advanced apparatus for testing the calorific power of coal employs small motor-driven stirrers in the calorimeter motor jackets, and this application of electricity is finding a wide usefulness in all cases where an even distribution of liquids heated, is essential.

At Clark University the specific heat of iron at high temperatures is now being investigated through the agency of the electric furnace and the thermocouple, and the distillation of mercury in vacuo by electrical methods has been found to be much cheaper than by the use of gas, even with electricity at 15 cents per kilowatt-hour and gas at $1 per thousand cubic feet.

In the electric distillation of mercury the apparatus is equipped with a heating coil which can be connected to an ordinary 110-volt circuit and left to operate all night, if necessary; in case the supply of mercury becomes exhausted, a relay circuit through the mercury reservoir is automatically opened, and the 110-volt current is thus cut off. When gas is used for the distillation of mercury the apparatus requires constant watching, and the fire risk is, of course, never absent. With about 150 watts in the heating coil an ordinary skillet full of mercury can be distilled by electricity in a single night.

Miniature incandescent lamps are now widely used for the illumination of many pieces of apparatus which would be ruined by gas or oil lights. When telescopic work of great accuracy is required in the reading of

slight movements in enclosed tubes, chambers, etc., the miniature incandescent lamp plays a valuable part. The exploration of the depths of liquids is often possible in no other way than by the use of electric incandescent lamps. The storage battery, also, is a useful adjunct in all laboratories where constant currents and potentials are needed.

The range of processes in which electricity is the active agent is so great as to be beyond the scope of these comments. The fields of electrochemistry and electrometallurgy involve large uses of electricity for the separation and the union of compounds. Some of these industries employ electricity on so vast a scale that the processes cannot be designated as laboratory work, although the laboratory plays a vital part in maintaining the production economy at a high pitch.

Any mention of the value of electrical apparatus in the research laboratory would be incomplete without a reference to the telephone. Laboratory work is branching out into departments, and the importance of quick communication is likely to increase as time passes. Concentration of every resource is needed in the scientific research of the twentieth century.

Book News

Electric Wiring Diagrams and Switchboards

By Newton Harrison. Size, 5 by 7½ inches. 272 pages. 105 illustrations. Published by the Norman W. Henley Publishing Co., New York. Price $1.50.

In this book the author has described the theory and design of wiring circuits and furnished an excellent practical guide for wiremen, contractors, engineers and architects. It is necessarily elementary in some parts, and wiremen particularly should find it of value in learning the theory of the art.

The relationship of volts, amperes, and ohms is taken up first. Next, under drop of potential, is considered the calculation of drop, finding the circular mils of wire, and obtaining the gauge number without a table. Simple circuits and those of more complex design are dealt with. The principles of switchboard design are taken up with reference to shunt and compound-wound generators. The characteristics of these machines are also described.

In dealing with alternating currents, the author has avoided intricate mathematical calculations, and has just given enough of the theory to show the meaning of the various units and the methods of obtaining their values. Sizes of wire for single-phase, two-phase and three-phase circuits are worked out, and the operation of the three systems is briefly described.

Radio-Activity

By E. Rutherford. Published by the Macmillan Company, New York. Size, 6 by 9 inches. 580 pages. 108 illustrations. Price $4.00.

During the year following the appearance of the first edition of this book, numerous researches have been made, of so important a character that a revised edition was necessary. Three new chapters have been added, giving a detailed account of the theory of successive changes and of its application to the analysis of the series of transformations occurring in radium, thorium, and actinium.

There is also a large amount of new material regarding the nature and properties of the radiations and emanations. In Chapter II. has been added a short account of the magnetic field produced by an ion in motion, of the action upon it of an external magnetic and electric field, and of the determination of the velocity and mass of the particles of the cathode stream.

Two appendices have also been added, one of some work upon the alpha rays, and the other of the chemical construction and geologic age of various radio-active minerals, and of the localities in which they are found. The sections and chapters which have been either partly or wholly rewritten are given in a list with the contents table.

Synchronous and Other Multiple Telegraphs

By Albert C. Crehore. Published by the McGraw Publishing Co., New York. Size, 6 by 9½ inches. 124 pages. 42 illustrations. Price $2.00.

Of the three parts into which the book is divided, the first deals with the methods of obtaining independent telegraph circuits on the same wire by the use of direct and alternating current. The receiving and transmitting apparatus of the duplex-diplex system are described, and also the applications of the system. Alternating and direct-current quadruplex and low-frequency duplex-diplex systems are briefly treated.

The second and third parts are devoted to the methods of obtaining telegraph circuits by means of the synchronous rotation of two bodies at distant points. The second part describes the means employed for obtaining the synchronous rotation, and the third tells of the way in which this rotation is employed for getting independent telegraph circuits.

The author frankly acknowledges that most of his results were obtained by laboratory methods. In the first part "artificial" wires were made to imitate "real" wires, but the results were almost identical with those of actual practice. This leads the author to believe that in studying new systems of telegraphy good results may be obtained in the laboratory.

Experience with synchronous telegraphs was also had in this way, actual instruments being used on artificial wires. Synchronous motors operating on wires used for no other purpose are first dealt with, followed by those on wires used also for telegraphs. Of the latter, those described are used on the single Morse wire, the duplex wire, and the multiplex wire.

The application of these motors to the operation of telegraphs is next considered, the concluding chapter dealing with the operation of particular systems on Morse circuits.

Electric Railway Accounting

By W. B. Brockway. Published by the McGraw Publishing Co., New York. Size, 5½ by 8 inches. 84 pages. Price $1.25.

This little book deals with the making of financial reports and the keeping of accounts of electric street railways. What a report should be, and its form, are dealt with, suggested types being offered. The relation of operating expenses to earnings and other units of comparison are discussed, and the use of curves for showing income, expenses, and operating statistics is illustrated.

Statistical information, the author thinks, should not be confined to dollars and cents, but should include all the operating features. Succeeding chapters are devoted to the standardization of accounts, the balance sheet, accrued and suspended accounts, and expert examinations. Contrary to the opinion of some, says the author, the accounting department is not revenue-producing; it is revenue saving.

He also deals with the qualifications of a railway accountant, and protests against putting the department in a room, or series of rooms, not needed for other purposes. Taking things for granted is to be avoided in accounting, but "old-maidish" care is undesirable.

An electric tramway is to take the place of the horse and steam system from Athens to Piraeus, in Greece.

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The Electrical Age Co.
New York and London

Alternating-Current Electric Systems for Heavy Railway Service

By B. G. LAMME

From a Paper Read at a Recent Meeting of the New York Railroad Club

In the problem of heavy electric traction, the method of procedure has been very much the same as in other engineering undertakings. The first and most natural means used was that which had shown such remarkable results in light traction work, namely, the direct-current system. In the application of this to heavy work, however, the necessities of the problem led to the development of a number of adjuncts, such as the rotary converter or motor-generator sub-station for transforming from alternating to direct current, the use of the third rail instead of the overhead trolley on account of difficulty in collecting current, and other features of lesser importance.

At this point the author discussed the advantages of rotary converters in transforming directly from one electrical form to another, over motor generators in which electrical energy is first changed to mechanical energy and then back to electrical energy, indicating in a general way, why a rotary converter sub-station has been given preference over the motor generator method.

The next development was owing to the increase in size of car equipments. As the overhead trolley wire limited the amount of current supplied to the car apparatus, the third-rail system was developed to overcome this difficulty.

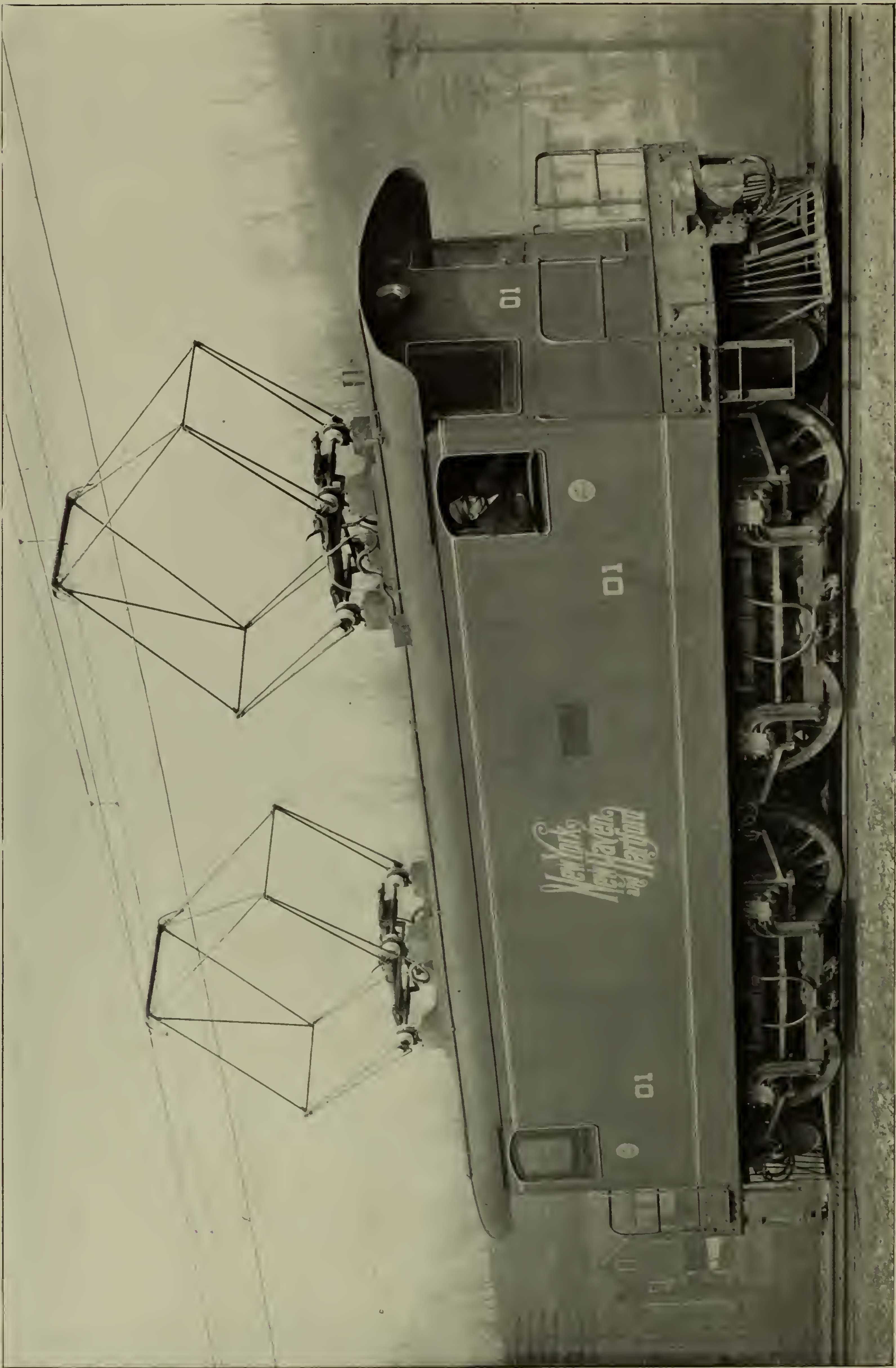
Even with the above two vital modifications of the direct-current system, it is found, as heavy railway conditions are approached, that one of the weakest links in the system is the voltage drop between the transforming sub-stations and the car or locomotive. This is due primarily to the enormous currents which must be handled with the usual 550 to 650-volt direct-current system. Suggestions have been made by prominent engineers that this difficulty should be overcome by increasing the direct-current voltage to 1000 or 1500 volts. However, this solution has not been pushed extensively by the principal manufacturers of electric apparatus, as it is felt that this would be only a partial step in the solution of the problem, like the transforming sub-station and the third rail, and also because there are certain inherent tendencies for trouble in the present 600-volt apparatus, which would be greatly exaggerated at much higher voltages.

AN ARMATURE WITH QUILL FOR THE ALTERNATING DIRECT-CURRENT LOCOMOTIVE, BUILT BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG, PA., FOR THE NEW YORK, NEW HAVEN & HARTFORD RAILROAD

While the above development was being carried on, the problem was being considered in other ways. Many engineers objected to the third rail for general use, believing that a live conductor should not be located so near the ground, and that the place for the trolley wire is overhead. Recognizing that high voltage for transmission is necessary, but that, after transformation to direct current, there remains the difficulty of collecting large currents from an overhead wire, it occurred to many that a more suitable solution of the problem could be obtained by supplying the high-voltage, alternating current directly to the trolley wire and then utilizing it, either directly or indirectly, for propulsion of the car or locomotive.

PORTABLE SUB-STATION SYSTEM

Keeping in view the above trend of direct-current development, the most evident of such methods would be to



AN ELECTRIC LOCOMOTIVE BUILT JOINTLY BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG, AND THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, FOR THE NEW YORK, NEW HAVEN & HARTFORD RAILROAD. THIS LOCOMOTIVE OPERATES ON DIRECT CURRENT OVER THE NEW YORK CENTRAL PART OF THE NEW HAVEN SYSTEM AND ON ALTERNATING CURRENT ON ANOTHER PART OF THE LINE

put the rotary converters or motor-generator sub-station on the locomotive itself. However, as the ordinary electric car, even of large size, has practically no place for such a transforming sub-station, this method has not been given serious consideration for such equipment. However, in the case of heavy locomotives it becomes a possible one.

In theory it presents some very good points, but in practice a considerable objection is found in the size, weight, and cost of the sub-station which must be carried by the locomotive. It has been suggested that this sub-station be placed upon a tender equivalent to the present tender of a locomotive, and it has also been proposed that it be placed directly on the locomotive itself.

The type of sub-station which is feasible on a locomotive or tender, is much more limited than in the case of a stationary sub-station. For simplicity there should be but one overhead wire, and therefore the supply system should be single-phase alternating current. This practically limits the transforming equipment to a single-phase motor-generator unit. There are two types of single-phase motors having suitable speed characteristics for driving the generator, namely, the synchronous type and the induction or non-synchronous type. The synchronous type must hold rigidly in step with the frequency of the supply system, and when carrying heavy load it can be thrown out of step by a momentary break in the supply circuit. As such breaks are not uncommon in railway service, this type of motor is considered unsuitable. There remains then the single-phase induction type motor for driving the generator.

Assuming therefore, the use of a single-phase induction motor for driving the generator, it should be wound preferably for the full trolley voltage in order to avoid the additional weight of a step-down transformer. This motor must have a capacity sufficient for the maximum power of the locomotive, plus all the electrical and mechanical losses other than those in the motor itself. It is self-evident that in order to reduce the weight of the motor as much as possible, it must be run at very high speed.

It may be well to look a little closer into this motor-generator transforming set. Considering first, the motor, it may be said that the single-phase induction type motor in its simple form is one of the least effective types of electric machines which we have. It is non-starting, or starts very uneconomically as a distorted polyphase motor. Its power factor, or the ratio of its true power to the apparent power supplied it or the current and volts supplied, is not nearly so good as that of a polyphase motor of the same dimensions. Its output is only about half that of a good polyphase motor built on the same frame. It is, therefore, heavy in proportion to its output. It takes a fairly large current from the line at no load.

On account of its poor starting characteristics it would preferably be kept running when the power is shut off from the car motors, and it would, therefore, take considerable current from the line when the locomotive proper is running empty, or is at a standstill for a short time. On account of its magnetic losses and the high speed at which it should be operated, this motor would have appreciable losses, even when running empty, and would, therefore, be drawing energy from the line when the locomotive is coasting or is at a standstill. On a 25-cycle alternating system, such a motor could be built with two poles for 1500 revolutions per minute, or with four poles for 750 revolutions per minute, the number of poles necessary being a multiple of two. The lower speed machine would be somewhat heavier than the higher speed one, but its losses when running empty would probably be no greater, and could even be less.

Taking up next the direct-current generator driven by the motor just mentioned, it is seen from the above that it will be run at either 1500 revolutions per minute, or at 750 revolutions per minute, as it would preferably be direct driven. The higher speed generator, being the lighter one, would naturally be chosen if this speed is not too high to permit the construction of a first-class generator of the required output.

Taking, for instance, an electric locomotive of the above type, and corresponding in capacity to those being built for the New York, New Haven & Hartford Railroad, it would be necessary at times that the generator deliver an output of 1500 KW. (2000 H. P.) or more. Moreover, the load fluctuations would be violent, and therefore a machine of first-class commutating ability is required.

The writer does not consider that any direct-current machine now built, with the above capacity and with a speed of 1500 revolutions per minute is sufficiently good for such service. This, therefore, implies a generator of questionable characteristics, or the choice of a speed of 750 revolutions per minute. At this lower speed the size of a motor-generator of the above capacity may be too great to be placed on the locomotive itself, although the weight and cost may not be much greater than for the higher speed unit.

For the purpose of comparison, motor-generator units corresponding to the above New Haven Locomotive conditions were worked out some time ago. The approximate results are as follows for both outfits:—

Speed	1500 R. P. M.	750 R. P. M.
Approx. weight	47,000 lbs.	54,000 lbs.
No load losses	65 H. P.	65 H. P.
Combined efficiency at 750 K. W. (1,000 H. P.)	90 per cent.	90 per cent.
Loss at 750 K. W.	110 H. P.	110 H. P.

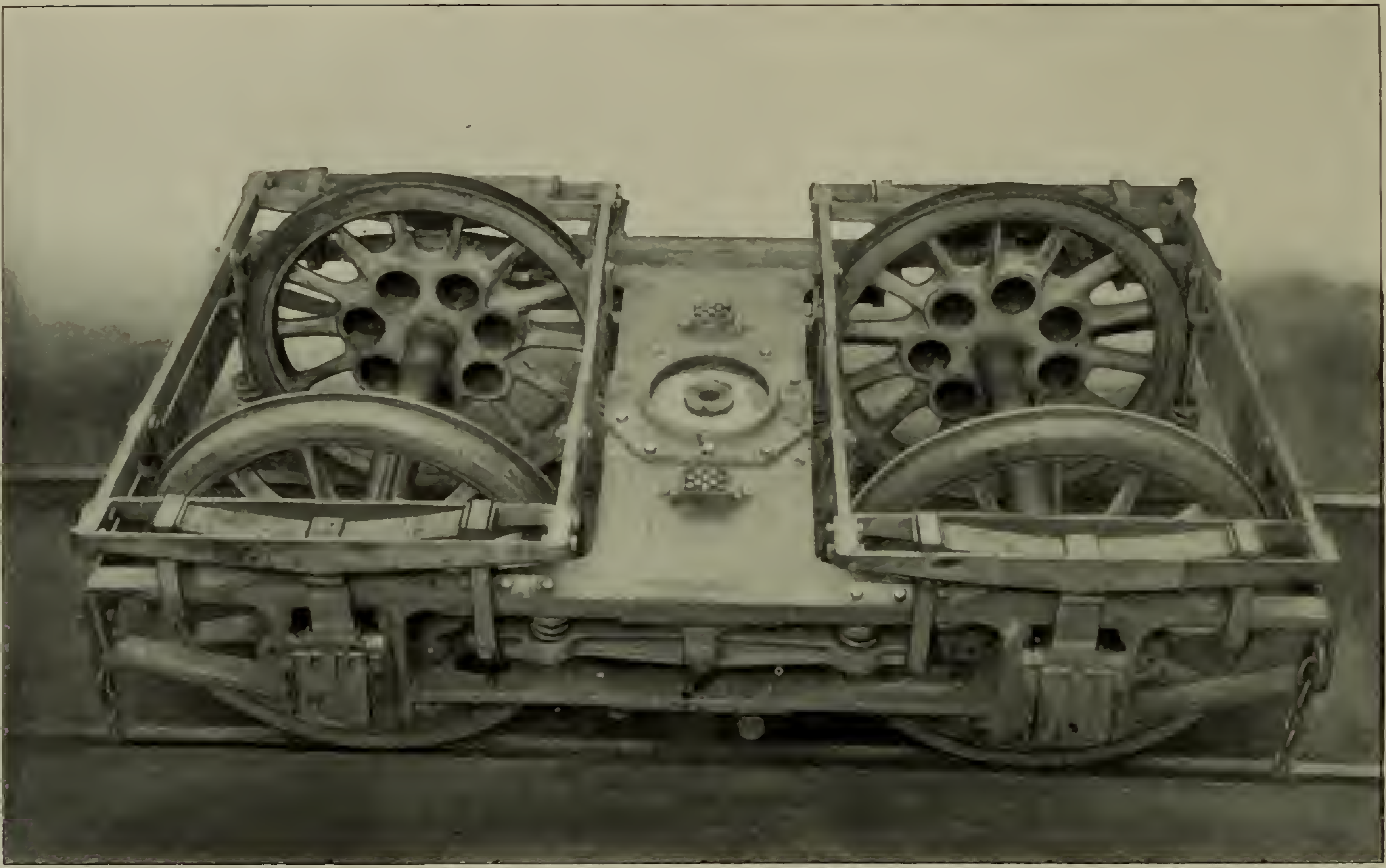
The above weights include starting apparatus, exciter, etc., but do not include the massive base plate which is usual with stationary motor-generator sets, as it is assumed that the frame of the locomotive could be made stiff enough to serve for the base. The locomotive structure might require some additional weight, which should also be charged against the portable sub-station outfit. However, the first named unit was not considered a practicable outfit, from the operating standpoint.

Assuming, however, that such a motor-generator set could be used, it would permit some very neat features as regards operation of the locomotive. In case it is to be on an alternating-current trolley circuit exclusively, so that the motor-generator set is always used, then the ordinary direct-current control apparatus can be almost entirely eliminated, for the speed of the car motors can be controlled by varying the direct-current voltage delivered by the motor-generator in the manner proposed by Leonard, namely, by varying the field excitation of the generator.

In this way, any speed within the range of the apparatus may be obtained efficiently, as there are no armature rheostatic losses and the power supplied is practically in proportion to the load. However, with this method of control, a separate exciter is required for the direct-current generator, as a self-exciting machine could not be controlled over a sufficiently wide range.

If, however, the equipment must operate on both alternating and direct current, as in the case of the New Haven electric locomotives, then a complete complement of direct-current controlling apparatus must also be used, as the motor-generator will be out of service when the locomotive is on the direct-current trolley.

In addition to the efficiency of



ONE OF THE TRUCKS OF THE NEW HAVEN LOCOMOTIVE. THE FRAME, TRUCKS AND CAB WERE BUILT BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA

speed control, this motor-generator scheme possesses another feature which may be of value in special cases. This is its ability to feed energy back into the high voltage alternating-current line by suitably exciting and controlling the car motors so that they can be made to operate in a stable manner as generators of power, this being fed into the motor-generator set, transformed, and returned to the line, minus the usual commission, of course. This may be of considerable advantage in letting trains down long grades. In ordinary braking, however, it is a question whether it is worth the complication, as it means that special provision must be made for exciting and regulating the fields of the car motors.

In general, it may be said that the disadvantages of the motor-generator scheme are found in the size, weight and cost of the apparatus, and the relatively high continuous losses; also, there are objections, from the mechanical standpoint, to carrying a motor-generator operating at high speed. The advantages of this scheme lie in the efficient speed variation, simplified control, and the ability to return energy to the high-voltage line, however, at the price of additional complication.

THE POLYPHASE SYSTEM

Another method of solving this railway problem, based on using existing methods and means, is that in which the well-known polyphase alternating motor is used. The polyphase induction motor has long been used in stationary work in connection with high-voltage transmission circuits. At first glance it would appear as if this motor should also furnish a solution of the railway problem where high trolley voltage is required. Many of the manufacturers of electric railway apparatus have given this method careful study, and a number have even given it a commercial test on a more or less extended scale. Some of those manufacturers who at first advocated it, have since dropped it, while others, particularly the Ganz Company, of Budapest, are still very favourable to it.

Various reasons are given for the attitude of those who have discarded or who have not adopted this system. The most obvious of these reasons are as follows:—

At least two overhead trolley wires.

The constant speed characteristics of the induction type motor, preventing efficient speed variation.

General structural features of the induction motor at the usual commercial frequencies.

Taking the first point, it may be said that the use of two overhead wires with a high difference of potential between them is considered very objectionable by many engineers. Those advocating this system have usually talked moderate trolley voltages such as 3300 volts. While higher voltages may be possible, there is no doubt that the trolley problem becomes increasingly difficult with increased voltage, and the current collecting devices, switches, crossovers, overhead equipment of the yards, etc., present serious problems.

The constant-speed characteristics of the induction type of motor have come in for much criticism when used for railway work. One law of the induction motor is that it requires a given amount of power to develop a given torque or turning effect, regardless of the speed at which it is running. At full speed, the power supplied to the motor appears as useful output, with the exception of the losses in the motor itself. At one-half speed, the same power applied gives but one-half full output, the remaining power being wasted in heat. At one-tenth speed, nine-tenths the power is wasted.

The reduction in speed is there-

fore obtained with this motor in the same way as a corresponding reduction could be obtained with a friction clutch; namely, by wasting part of the power as heat. With an induction motor, therefore, there is no such condition as power consumption in proportion to the speed, but the power consumption is constant, regardless of the speed. It is evident, therefore, that the induction motor, in its usual form, is an inefficient piece of apparatus where the speed must be varied. This difficulty is overcome to a certain extent by using two or more motors arranged in the so-called "cascade" or "tandem" connection. With this connection, a part of the power which would be wasted at lower speed in the case of a single motor, is, instead fed into a second motor and utilized to a greater or less extent. However, there is but one speed at which these two motors, connected in tandem, can operate efficiently, and below this speed the power is again wasted.

The two motors in tandem act as if a single motor had been geared for lower speed. The result is the same as if one constant-speed motor had been used with a high and a low gear, to give two changes in speed. These two speeds correspond to the efficient running conditions. By the addition of a friction clutch for intermediate conditions and the use of gears with two speed ratios with a single motor, we approximate closely the conditions of operation, as regards economy, that would be obtained with two induction motors arranged to be operated singly and in "tandem."

Normally the induction motor, in comparatively large sizes, closely approximates a constant speed between no load and full load. The variation in speed within these limits will usually be less than 2 per cent. Two such motors rigidly connected to the same load must have the same speeds or they will not divide the load equally. Assuming that the normal speed variation in the motor is 2 per cent., and that one pair of car wheels or drivers is 2 per cent. smaller than the other, then one motor will tend to run 2 per cent. faster than the other at all times. They will, however, automatically adjust themselves for equal speeds by unbalancing their loads. At no load one would tend to take half its rated load as a motor and thus drop 1 per cent. below synchronous speed, while the other would tend to raise 1 per cent. above synchronous speed, and carry half load as a generator. The resultant would be equal to no load, but each motor would, however, be carrying half load.

Again, at half the rated load of the two motors, one would tend to carry no load and the other full load. In the same way at full load for the two motors, one would carry half load and the other one and one-half load. The difference in load between the two motors in this case is always equal to that load on one motor which would be required to give a drop in speed equal to the difference in speed between the car wheels or drivers. With 4 per cent. difference between the drivers, the unbalancing would correspond to the load required to drop one motor 4 per cent. in speed, or about double load on the basis of a drop of 2 per cent. at full load.

This difficulty can be overcome in a single locomotive by keeping all drivers of the same diameter or by the use of side rods, but this it not feasible when a number of separate locomotives are to drive the same load. When it is borne in mind that the drivers of different locomotives may have as much as 6 per cent. or 7 per cent. difference between the diameters of their drivers, it is evident that the unbalancing of the load between two locomotives may amount to much more than their normal rated capacity unless the slip of the drivers equalizes them.

One method of equalizing the loads would be to drop the speed of all the locomotives to that of the lowest one, by connecting suitable resistance into their motor circuits. This would be effective for one given load, but would not give suitable equalization for other loads. For example, with 6 per cent. difference in diameter of drivers of two locomotives, one would tend, when running empty, to carry one and a half times load, receiving power from the line, while the other locomotive coupled to it would carry one and a half times load as a generator feeding back into the line. The use of resistance would lessen this extreme unbalancing, but could not eliminate it entirely, as there must be some load on the motors in order that the equalizing resistances may become effective. It is thus evident from the above, that only an average equalization of load would be practicable.

Taking up the structural features, it may be said that the induction motor is not particularly well adapted for railway work at the usual frequencies of alternating-current circuits, but the reason for this is somewhat too technical for the scope of this paper. However, the Ganz Company, of Budapest, has avoided, to a greater or less extent, a number of the structural limitations by reducing the frequency of the supply system to 15 cycles per second instead of 25 cycles, the lowest in general commercial service in the country.

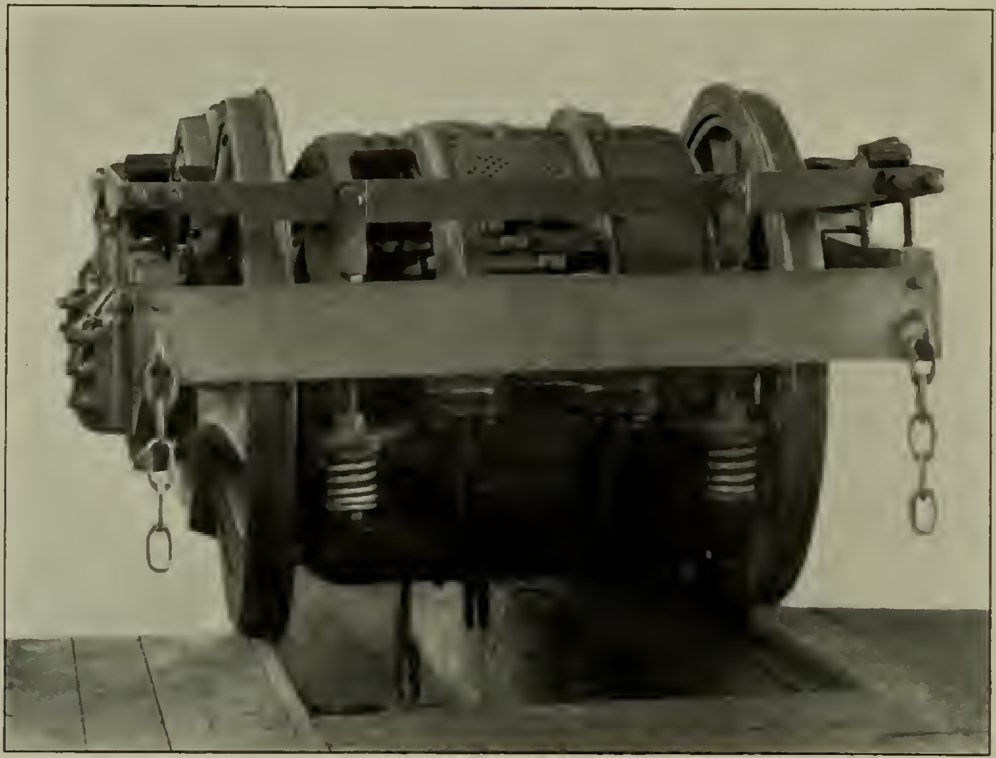
This low frequency presents no

A DRIVING WHEEL WITH CAPS REMOVED TO SHOW THE POCKETS FOR THE DRIVING PINS

particular disadvantages at the generator station, except in the case of small steam turbines, which can have a maximum speed of only 900 revolutions per minute. The frequency of 15 cycles per second is equal to 1800 alternations per minute, which is equal to the number of generator poles multiplied by the revolutions per minute. As the least number of poles is 2, the highest possible number of revolutions is 900. This speed is lower than desired for steam turbines, except those of large capacity.

In the transmission line, however, the use of this low frequency in itself is advantageous, as it gives less line drop and loss than with 25 cycles. All transformers, however, become somewhat heavier. The real gain with this frequency is in the motor, which can be given better proportions and characteristics.

Among the advantages claimed for this system is its ability to return power to the line under certain conditions. When the induction motor is run above its synchronous speed it acts as a generator and returns power to the line. If a car equipped with such motors be started down grade with the power on, it will speed up until the motors run above the synchronous speed. Below synchronous speed, the induction motor acts as a motor. At synchronous speed it does no work. Above synchronous speed it acts as a generator, but it cannot deliver power efficiently except when running but slightly above synchronous speed. If it is desired to run much above synchronous speed, resistance must be connected in circuit just as in the case of the motor when running much below speed, and the efficiency in returning power to the line is affected by the rheostat in the same way as its efficiency as a motor is affected by the use of resistance. When running 50 per cent. above synchronism, a considerable amount of power is wasted, just as when running 50 per cent. below speed.



END VIEW OF A TRUCK SHOWING THE MOTOR IN PLACE

In this and in the preceding cases where mention has been made in regard to returning power to the line, it must be kept in mind that there must be some load connected to the line which can absorb this power. A single locomotive on the line cannot return power advantageously because there is no load except the normal light load losses in the line and transformers. Therefore, the return of energy would possess no particular advantages, as the practical way to get the additional load would be to connect a rheostat across the line and thus waste the power returned to the line. However, in a system where there would always be a number of locomotives in operation with a considerable portion of them taking power from the line, there would be some advantage in restoring power.

ARNOLD'S ELECTRO-PNEUMATIC SYSTEM

Another method of solving this railway problem with high-voltage trolley, was that proposed and tried by B. J. Arnold. He recognized at an early period the advantages that could be obtained with high voltage and a single trolley wire, and he therefore adopted single-phase alternating current for his supply system. However, it was again attempted to carry out the work with tools at hand, and the only motor available at that time for use on his single-phase trolley system was the single-phase induction motor. As already mentioned in connection with the motor-generator method, this motor has very bad characteristics in regard to starting, overload capacity, etc., and Mr. Arnold therefore proposed to supplement the single-phase motor with certain compressed air appliances which would furnish the characteristics lacking in the motor itself.

The motor was intended to run at or near its normal load most of the time, while the air apparatus was to do the starting and was to assist in taking care of abnormal conditions. Variable-speed operation was also to be obtained by means of the air apparatus. This system differs much from the preceding ones, and one notable feature was that the electrical apparatus was in reality a minor feature of the scheme, many of the desired locomotive characteristics being obtained by mechanical means, as distiguished from electrical.

SINGLE-PHASE SYSTEM

By this time the problem was becoming better understood and at this stage another system was brought forward which was specifically designed to meet the varied conditions of heavy traction service. This system contains the following features:—

1. Facilities for transformation.
2. One trolley wire only is used.
3. Any desirable voltage can be used on the trolley line.
4. An efficient means for varying the voltage to the motors is obtained. With single phase, there is only one supply circuit to be handled, and the variable voltage apparatus can be given the simplest and most efficient form.
5. A type of motor was developed, which can have its speed varied by varying the voltage supplied to it, and which uses power practically in proportion to the load, when operated in connection with the above variable voltage supply circuit.
6. The motor is preferably wound for low voltage, and the same transformer which is used for stepping down from the trolley voltage to the motor voltage, can also be used for obtaining the desired voltage variation, for varying the speed and the power in proportion to the speed.
7. The motor is inherently of a variable-speed type and can automatically adjust its speed to that of other motors driving the same load, with but very small unbalancing of the loads on the individual motors.

8. The type of motor developed is one which can be used on direct current also.

There are several variations in the types of single-phase motors used by the different manufacturers, but the principal features of the system are common to all. In its characteristics of variable speed over any desired range, and consumption of power in proportion to the load, the single-phase equipment is on much the same footing as the steam locomotive. The equipment also possesses the ability to operate at increased speed by increasing the voltage above the normal and can thus make up for lost time when desired.

It is important that under certain conditions an electric locomotive should be able to act as a brake, or to return energy to the line, as when taking loads down grade, for instance. There is but one way in which the car equipment can act as a brake, namely, by reversing the function of the motors and converting them into generators of power, the driving power being furnished by the train in movement. In acting as generators there are two ways in which an electric equipment can expand its power:—First, by wasting it in resistance as heat, and second, by feeding it back into the line in case there is any other load on the line which can absorb the power.

The motors of the single-phase system can readily meet the first of these conditions, namely, that of feeding power into a resistance. As the motors are of the commutator type, and are, in reality, first-class, direct-current machines, they will readily pick up as direct-current generators and can feed power into a suitably proportioned resistance. This method of braking is perfectly feasible, provided the controlling apparatus and car circuits are arranged for this purpose.

Consider, next, the case of feeding power back into the line and controlling it. It would appear when looking at the problem broadly, that a motor which could have its speed and power varied so economically over a wide range, should also be capable of reversing its functions and becoming a generator of power with an economical control over a wide speed range; and it has been determined in an extended series of shop tests, that the single-phase type of railway motor does possess this property under certain conditions.

A number of ways of doing this in a more or less successful manner have been tried. Some of these methods are very effective and permit practically perfect control of the power and speed during braking, or when returning energy to the line. Such an arrangement would probably not be advisable for merely stopping trains. Its true field would be in letting a train down a grade of such length that the power is returned to the line for a long enough period to represent a fair proportion of the total time of operation. Both this method and that where the power is absorbed in a rheostat, are valuable in relieving the wear of the brake shoes, which is a very important item on very long grades.

The resistance method of braking, although not as efficient as the other, has one advantage, in that it is independent of the supply system. Therefore, in case the power goes off when the train is descending a grade, the resistance method of braking would still be effective.

In the past few months, two contracts have been taken by the Westinghouse Electric & Manufacturing Co., of Pittsburg, for single-phase railway equipments involving locomotives of steam railway size. These are for the equipment of part of the New York, New Haven & Hartford Railway system, and for the electrification of the St. Clair or Sarnia tunnel, under the Detroit River, on the Grand Trunk Railway. The former equipment will operate under high-speed passenger service conditions, while the latter approximates freight locomotive conditions. A brief description of these two proposed installations may be of interest.

THE NEW HAVEN SINGLE-PHASE EQUIPMENT

In this case the problem is somewhat complicated by the fact that the locomotives must operate on direct current over the New York Central part of the New Haven system, and on alternating current on its own part of the line. However, this complication is not nearly so great as would appear at first thought, for the type of locomotive chosen is one which adapts itself well to both classes of service.

However, there is necessarily some duplication of parts on the locomotive, such as the collecting devices, certain details of the controllers and wiring. On the other hand, it is surprising how many parts are common to both classes of service. As the New Haven equipment in its alternating part embodies many features which have been carried out further than ever before, it may be of interest to describe it as a whole.

GENERATING PLANT

The main power house is at Riverside, about three miles from Stamford, Conn. The generators in this power house are to be driven by steam turbines. The machines have single-phase ratings of 3750 KW., or about 5500 KW. on three-phase, the armature winding being such that three-phase current can be obtained from the same machine. The generators have two poles and at 1500 revolutions per minute give 3000 alternations per minute or 25 cycles per second. A 5500-KW., three-phase, two-pole generator, running at 1500 revolutions per minute, would have been considered an impossibility only a short time ago.

The design of these generators was one of the difficult problems in

TWO STEP-DOWN TRANSFORMERS OF THE TYPE HERE SHOWN ARE USED TO LOWER THE LINE PRESSURE OF 11,000 VOLTS TO 600 VOLTS

this undertaking. The difficulty, however, was in designing the machines in the first place, and after a suitable construction was worked out, the manufacture of these machines appears to be comparatively easy. The machines have an ample margin, both electrically and mechanically, and they are particularly well adapted for handling inductive loads. As an illustration of unusual conditions met with in the design of such machines, it may be said that a single complete armature coil weighs about 600 pounds. However, as the machines have only two poles, the total number of armature coils is relatively small. As a machine in such service is liable to have rather short circuits at times, the armature end windings are extremely well braced.

As these machines are to feed directly into the trolley system, they are wound for the normal trolley tension of 11,000 volts, and in consequence, one terminal of each machine is always grounded when in service, as in usual practice with direct-current railway generators. This point has been fully kept in mind in the design of these machines.

As the New Haven Railway Company contemplates operating certain existing direct-current systems from this power house, it was decided to add an additional leg to the armature winding so that three-phase currents could be obtained for feeding into rotary-converter stations for furnishing direct current for some direct-current lines, which, at the present time, cannot be conveniently changed to straight alternating current. The New Haven Company also has other fields for three-phase power, which it proposes to take care of as soon as it is feasible to do so.

The steam turbines for driving these generators are of the well-known Westinghouse-Parsons type. On account of the large output and high speed, an unusually good performance is indicated. The engines are designed for the single-phase rating of the generators, as it is anticipated that the heavy service and the load peaks will be due to the railway load.

OVERHEAD TROLLEY SYSTEM

As 11,000 volts will be applied directly to an overhead trolley, and as the trolley system will span from four to six tracks, it is evident that a very substantial overhead construction must be used. The construction of this overhead system is one of the most interesting features in this whole electrical system.

The trolley system is to be suspended from steel bridges which span from four to six tracks normally, and even a greater number at special points. These bridges are placed at intervals of about 300 feet, and at points about 2 miles apart, heavier structures, called anchor bridges, are placed.

The steel cables which support the trolley wire proper are supported by massive insulators on the bridges. Two cables are used for each wire and form a double catenary suspension carrying the trolley wire by means of triangular supports. The double system of suspension gives increased stiffness to the trolley construction. The triangular supports are placed about 10 feet apart. The steel cables have a total sag of about 6 feet, while the trolley wire itself is maintained in a practically horizontal position.

At points corresponding to the anchor bridges, that is, about 2 miles apart, each trolley wire is broken by section insulators and is connected to the other trolley wires and to two feeder wires through automatic circuit breakers. Otherwise each trolley wire, with its cables and supports, is insulated from the adjacent wires. In this way each wire is sectioned and a short circuit on any one section can cut it out without putting the neighbouring wires out of service. The two feeder wires just mentioned are carried the whole length of the alternating system, and by means of these and the arrangement of automatic switches, any entire section of four or more trolleys could be cut out of service and the sections beyond can be kept in service.

The trolley wire has a nominal height of 22 feet above the track. This height will vary a few inches up or down with wide variations in temperature. The pantagraph type of trolley used on the locomotives has an effective range of about 8½ feet and therefore a very considerable variation in the height of trolley is permissible.

The overhead system is designed to be amply safe under abnormal conditions, such as high wind or a heavy coating of ice. The stresses in the supporting cables with a load of ice ½ inch thick each side, or 1 inch total, on the cables, hangers, etc., will be about 1-6 of the ultimate. The stresses in the structure due to wind have been figured on a basis of 16 2-3 pounds per square foot, projected surface for the cables, and 25 pounds per square foot normal surface for flat surfaces. This is on a basis of the cables being covered with ice as given above. Allowance is made for double these pressures in summer when there is higher wind velocities, but under this condition the cables will be of much smaller diameter in the absence of ice.

As 11,000 volts are used on the trolley system, no transforming stations are necessary on the part which is now to be installed. The high-voltage trolley system will extend about 19 miles in one direction from the power house and about 3 miles in the opposite direction to Stamford. This system could be extended in the latter direction approximately 20 miles further, if desired, without transforming sub-stations. Therefore about 40 miles of the trolley system can be supplied directly from the main power house. With a locomotive load representing 4000 KW. about 19 miles from the power house, and a corresponding load 15 miles away, or 4 miles from the power house, the drop at the end of the line will be about 13 per cent.

This drop is on the basis of feeding into the load from one direction only. If there were a transforming sub-station about 40 miles away from the power house, feeding into the same trolley system, then the drop at a point 20 miles away would not be 13 per cent., but would be considerably less as power would be supplied from both directions. It is apparent, therefore, that with sub-stations along the line feeding into a common trolley system, such sub-stations could be possibly 60 miles apart. For example, if a transforming sub-station were placed in New Haven about 40 miles away from the power house, the drop at the midway point between the sub-station and power house would be equivalent to a load on the present system at 10 to 15 miles from the power house. However, the above distances between sub-stations are so great that it might prove inadvisable to feed more than one or two sub-stations from a given plant, two or more power plants being installed on a very long system.

THE LOCOMOTIVE

This is the part of the electrical equipment which will doubtless excite the most interest, principally because it is a newcomer in an old field. From the standpoint of the designer the generating system and overhead construction may present just as interesting features, but to the layman in the electrical field there is but little with which to make comparison; but when it comes to the locomotive the general problem is much better understood.

The frame, trucks and cab of this locomotive were built by the Baldwin Locomotive Company, of Philadelphia, on designs developed after many conferences between the New Haven Railroad Company, the Baldwin Locomotive Company and the Westinghouse Electric & Manufacturing Company. The design adopted was partially determined by the fact that the motor equipment must be suitable for use on both alternating and direct current. This to a certain extent controlled the number and size of the motors and thus affected the construction of the trucks and other parts. The results have turned out so well, however, that there is every reason to believe that this type of locomotive will be used in future even where alternating current alone is used.

The mechanical construction of the locomotive presents many novel and interesting features which deserve special consideration. The running gear consists of two trucks, each mounted on four 62-inch driving wheels. The length of wheel base is 8 feet. The side frames are of forged steel, and to them are bolted and riveted the pressed steel bolsters carrying the center plate. The weight on the journal boxes is carried by semi-elliptic springs with auxiliary coiled springs under the ends of the equalizer bars, to assist in restoring equilibrium. The bolsters are 30 inches wide at the center plate and are widened, where bolted to the side frames to nearly double this amount, thus giving a very strong construction without excessive weight. The center plate which transmits the tractive effort to the frame is 18 inches in diameter and will be lubricated to permit a perfectly free motion in curving. The truck centers are 14 feet 6 inches apart.

Owing to the fact that the entire space between the wheels is occupied by the motors, it was impossible to transmit the drawbar pull through the center line of the locomotive in the usual way. Instead of this, strong plate girders heavily cross-braced are carried outside of the wheels, and the entire strain of the drawbar is carried to these through strong box girders having top and bottom plates 42 inches wide.

Directly underneath the girder at each end is a Westinghouse friction draft gear, to which the drawbar is attached. The entire design lends itself to a very strong construction without great weight. The cab is built up of sheet steel on a framework of "Z" bars. Inside the cab the apparatus is carried on a framework of structural steel, which is built into the cab and firmly anchored to floor and ceiling. Over each motor is a large trap door which permits easy access to motor bearings and brushes.

The motors are four in number, each of 250-H. P. nominal capacity, but with a continuous capacity of over 200 H. P. each, or over 800 H. P. total. The motors are of the gearless type and are wound for a normal full load speed of about 225 revolutions per minute. They are connected permanently in pairs and require about 450 volts at the terminals on alternating current, and 550 to 600 volts on direct current.

The frame and field of each motor are split horizontally and can be removed in halves in order to give access to the inside of the field or to the armature. The armature is not placed directly on a shaft, but is built up on a quill through which the car axle passes with about $\frac{5}{8}$ inch clearance all around. On this quill, at each end, are placed bearings which carry the field frame.

At each end of the quill is a flange from which projects seven round pins, parallel to the shaft, into corresponding pockets in the hub of the wheel. Around each pin is placed a coiled spring wound with the turns progressively eccentric. These springs are contained between two steel bushings, the smaller of which slips over the pin, and the larger fits in the pocket in the wheel. These springs are amply strong to carry the entire weight of the motor, but are normally required to transmit only the torque of the motor and to keep the motor axis parallel to the axle. They allow a total vertical movement of about $\frac{3}{4}$ inch.

The end-play of the motor, instead of coming directly on the wheels, is taken by strong coiled springs, inside the driving pins, pressing against covers in the outer ends of the spring pockets in the wheels. The torque on the motor frame is taken by heavy parallel rods, which anchor the frame to the truck above and below the axle. These rods permit vertical or side motion of the motor, but prevent excessive bumping strains from coming on the motor driving springs. The entire weight of the motor is normally carried on springs supported from a steel frame surrounding the motor and resting on the journal boxes.

The motors are internally of the same general type which the Westinghouse Company has been building for some time for interurban service. However, due to the relatively low speed of the motors, the maximum commutator speed is very low, being less than 3000 feet per minute when the locomotive is making 60 miles per hour. This may be compared with 5000 to 7000 feet commutator speeds which are frequently attained in both direct current and alternating current high-speed service with fairly large motors.

One interesting feature in these motors is the method of cooling. As a blower is used in a locomotive for cooling the lower transformers, it was decided to extend this method of cooling to the motors also. In the floor of the cab is an air conduit of considerable size from which air is piped to each motor. This method of cooling improves the continuous capacity of the motors, as evidenced by the above figures, which show that the continuous rating is almost equal to the one-hour rating.

A further very great advantage in this method of cooling lies in the fact that the motors can be kept very clean, as the inside of the motor is kept under partial pressure at all times, tending to keep out dust and dirt, as all air-flow is outward. The air furnished to the motor, being taken from the inside of the cab, can be kept relatively clean and dry.

On the direct-current part of the line, current is taken from the third-rail system, except in the case of some short sections at cross-overs fed from an overhead trolley on direct current. The motors are controlled in the usual series-parallel method in combination with resistance, as in ordinary direct-current practice.

On alternating current, the motors are not operated in series-parallel as on direct current, but are connected permanently in a given manner, and the supply voltage is varied. This gives an equivalent of the series-parallel, except that the number of efficient operating steps is much greater. On alternating-current operation, no resistance is used in regular running, but a slight amount is used in passing from one working step to the next, this being in the nature of a preventive device to diminish the short-circuiting effect when passing from one transformer tap to another.

There are six operative voltages, or running points, on the alternating current, corresponding to six taps on the lowering transformer, where there is a small number of intermediate steps, which are used only in passing from one working point to another. Experience has shown that the number of steps on alternating current required to give a smooth acceleration is considerably smaller than required on direct current. In

consequence, the controller is so arranged that on alternating current about half as many steps are used as on direct current. The tests have shown that the acceleration on both alternating current and direct current is very smooth.

There is one feature in the direct-current control which is not generally found at the present time on direct-current equipments, namely, shunting the field for higher speeds. On the series position on direct current, the motors have an efficient running point. It is usual railway practice to pass from the series to multiple position by introduction of resistance, there being no intermediate efficient running speed. On the New Haven equipments, however, the type of motor used is one which permits an almost indefinite shunting of the field without affecting the commutation or operation otherwise, and advantage is taken of this to obtain several higher speeds by shunting the fields before passing into multiple. In this way several efficient running points are obtained between the series and multiple. The tests have shown that these motors will operate in a perfectly satisfactory manner on direct current, with their fields shunted down to much less than half their normal strength.

When operated on direct current, as stated before, the current is fed directly to the motors. On alternating current, however, step-down transformers must be used, as the alternating-current trolley voltage is 11,000. The step-down transformers are two in number, one on each side of the cab, in order to balance the weight in the cab. It must be borne in mind that these transformers are the heaviest single pieces in the cab, and there would be considerable difficulty in placing a single transformer to advantage. A further reason for two transformers is that an injury to one would not entirely disable the locomotive. The transformers are connected in parallel across the high voltage, but on the low-voltage side each transformer feeds one pair of motors, through a separate control unit. This means that the controller, when operated on alternating current, consists of two normally independent units.

The main controllers are of the well-known Westinghouse electro-pneumatic unit switch type. The design, however, differs somewhat from the straight direct-current type, due to the fact that switches, blowouts, etc., must operate on both alternating and direct current, as many parts of the controller are common to both. It may be mentioned also that the reversing switches are of the unit switch type.

The main controllers are operated from master controllers at each end of the cab. The controller system is arranged for mulitple-unit operation so that two or more locomotives may be coupled to the same load.

In addition to the controlling and transforming apparatus, a number of auxiliary parts, such as two air compressors driven by motors, can be operated on either alternating current or direct current, and two blowers are driven by similar motors, for furnishing air to the transformer and motors, and to the direct-current rheostat. It may be mentioned that the air which passes through the transformers is also sent through the rheostats. When operating on alternating current, the transformer is heating the air which passes through, and this air would not be very effective in cooling the rheostat. However, when running on direct current, the transformer is idle, and the air passing through becomes effective in the rheostat.

In addition to the above auxiliary apparatus there are oil circuit breakers for the high-tension alternating-current switches for throwing from alternating current to direct current, and many details which would be found in any electric locomotive. There is also a steam generator in the cab for the purpose of generating sufficient steam for heating the coaches in cold weather.

The locomotive is equipped with devices for collecting both alternating and direct current. For the latter there are eight collecting shoes, four on each side of the locomotive, arranged in pairs of two each. There are, of course, two pairs on each side, one at each end, for the purpose of bridging such gaps as are necessary in the third-rail system. There must be shoes on each side, as the locomotive must be able to make contact with the third rail when turned end about. These direct-current contact shoes must also be able to work on two forms of third rail, one in which the shoe runs under the rail and the other where the shoe runs on top of the rail. The locomotive is provided with a pantagraph, low-tension, overhead, direct-current trolley to conform with certain New York Central requirements.

For collecting alternating current, the locomotive is provided with two pantagraph-type, high-tension bow trolleys. Each trolley has a capacity to carry the total line current under average conditions, but two are provided to insure reserve capacity.

Each of these locomotives is to be able to handle a 200-ton train in local service on a schedule of 26 miles per hour, with stops averaging about 2 miles apart. In order to make this average speed the maximum speed will be about 45 miles per hour.

One locomotive will also be able to handle a 250-ton train on through service. For heavier trains than this, it is intended to couple two locomotives together and operate them in multiple. This presents no difficulties, for, as stated before, the locomotives are fitted up for the multiple-unit system of control.

It is evident from the above description that the engineers of the New Haven Railway Company have had in view the adoption of an electric system which is particularly well adapted for future extensions. If the electrification were to stop at Stamford, then the full advantage of the alternating system would not be obtained. However, the section which will be electrified with alternating current is of sufficient length to enable the New Haven Railway engineers to determine the advantages and possibilities for future extension, and it is safe to predict that such extensions will be made in a comparatively short time.

SARNIA TUNNEL

This equipment is to be on a relatively small scale as compared with the New Haven, as there are to be five locomotives of 750 H. P., which can be operated singly or in multiple as desired. These locomotives are to be of comparatively low speed, developing their rated horse-power at 10 to 12 miles per hour. The service is very intermittent.

On account of the low speed of these locomotives the motors are geared to the axles. As the normal axle speed is about 60 revolutions per minute, it is impracticable to get a motor of the required capacity into the available space, if made of the gearless type. The motors are therefore designed for a speed of about five times that of the axle.

Except for the fact that they are of the single-reduction type, instead of gearless, the motors are very similar in general features of construction to the New Haven motors. The whole equipment, however, is simplified somewhat by the fact that alternating current only will be used.

On account of the limited height of the tunnel, it is found advisable to use only 3300 volts on the trolley wire. However, as the length of the electric part of the system is comparatively small, this does not impose any very severe conditions. It

is probable, however, that in case the electric zone at either end of the tunnel should be greatly extended, it would be advisable to use 6600 volts on the additional sections, with transformers on the locomotives, so arranged that they could be switched from a 3300-volt connection to 6600-volt connection, or vice versa.

As this system as a whole has been very fully described in various technical journals it is not necessary to go into it more fully at the present time.

DISCUSSION

At the conclusion of Mr. Lamme's paper, W. J. Wilgus, vice-president of the New York Central Railroad, said that steam railroad men were prompted to change to electrification by the desire for the abatement of the smoke nuisance in tunnels or terminals in large cities, or the improvement of passenger service. To accomplish this, safety, reliability, and earning capacity should be borne in mind.

Regarding the safety of overhead wires as compared with the third rail, he would not like to be considered as condemning either, as local conditions require the use of either or both. The disadvantages of the third rail are the impedance with ordinary maintenance of track, the danger of derailments, troubles with snow and sleet, complications at frogs and switches, difficulties of current collection and danger to employees and trespassers. Extended experiments under his direction with a properly designed and protected rail have proved the fallacy of these objections.

The disadvantages of overhead construction are as follows:—Inelasticity of construction, which prevents extension of tracks, or changes of grade or alignment with radical alterations in the overhead structures; danger to trainmen on top of freight cars; danger to the public at overhead and highway bridges; danger to trains in tunnels and other places with restricted clearances; and danger to derailments knocking down a supporting structure.

Regarding the question of safety, then, it may be said that properly designed conductors, either third rail or overhead, offer as much safety as the present steam equipment, that both types are necessary for the full development of the art, and that between third-rail, direct-current systems, and overhead, alternating-current systems, a selection of either may be made to fit local conditions, with the preference from a non-electrical standpoint in favour of the third rail.

To provide against the crippling of the system by the possible failure of the power, the tower stations may be built in duplicate, so that in case one fails, the other may use its overload capacity and spare units. The New York Central & Hudson River Railroad had adopted this policy. Though this may be criticized as expensive, the surplus power may be utilized to take care of the expanding traffic of the company.

The transmission line should, when possible, be in duplicate, and the working conductor not used for transmission purposes. In other words, it should be sectionalized, to confine breaks to one section. Regarding the use of storage batteries, their cost is just as legitimate a charge against the use of alternating-current systems for heavy railway service as for direct-current systems, and even more so if one power station is used, as contemplated in the New Haven system.

The next speaker, Calvert Townley, consulting engineer of the New York, New Haven & Hartford Railroad, gave the point of view taken by his company in its prospective adoption of electric traction. Examining a railway map of Southern New England, one could see that the New Haven system is not a single line, but a net-work, its customers being the manufacturing towns in Connecticut, Rhode Island and Massachusetts. This makes for congestic traffic. Tidewater is near the lines for a considerable length, and this, coupled with the numerous water-powers in New England make the generation of power cheap. The New Haven system is, therefore, well adapted for electrification.

Although the problem was originally taken up because it was necessary to enter New York electrically, future necessities were borne in mind. The distance between New York and New Haven is 73 miles, and there is the possibility of electrification to New London, Hartford, Springfield and Boston. Thus it is necessary to provide, not only for a suburban traffic, but also a long-haul traffic with heavy units at intervals, which may be termed infrequent as compared with trolley-car service. Therefore the capacity of the line at any one point should not be dependent on the ordinary direct-current sub-station methods, which would greatly increase the expense.

As to reliability, in the alternating-current system, there is only one link between the bus-bar and the locomotive,—the trolley wire. With the direct-current system, there are an 11,000-volt, three-phase transmission, a high-tension switchboard, step-down transformer, rotary converters, a direct-current switchboard, a storage battery, direct-current feeders, and a 600-volt, direct-current trolley wire. On the other side, there was the possibility of trouble with high-tension current collection, as against the ordinary 600-volt collection.

With the alternating-current system the efficiency of the whole system was 10 per cent. better. With extension of lines, greatly increased service would be had without any continued maintenance expenses except that of the overhead construction. The voltage could be lowered at bridges, in tunnels, and other places. Regarding the sectionalizing of line, it will be noted from the paper that every 2 miles, each trolley wire is broken by section insulators, and is connected to the other trolley wires, and to two feeder wires, through automatic circuit breakers.

The New Haven controls a system of trolley lines in Connecticut, and desires to use them in connection with branch steam lines serving not very populous sections. The alternating-current system lines enable them to operate main-line trains over these branch lines and thus make the system uniform.

Frank J. Sprague, of the New York Central's electrical commission, said that the paper was not a discussion of the advisability of electric operation on trunk-line railways, but rather a specific plea for the substitution of single-phase electric locomotives operated directly at high tension in place of steam locomotives.

The electrification of trunk-line systems was more a financial than a technical question. Leaving out special problems, there are but two broad grounds on which a steam-operated trunk line should consider electrification, namely, hope of reduction in working expenses, with the concentration of the prime mover and possible use of water-power at a central station, and because there might be not only some gain in economy, but also something achieved impossible to steam operation, as, for example, a radical change in train science to increase the traffic.

Regarding the three principal methods of operation described in the paper, each was practicable and had certain advantages. He must, however, condemn the assumption that past practice measured the limit of voltage in direct-current operation. The increase to 1500 volts was not only possible with modified forms of construction, but it also made practicable the resuscitation and adoption

for locomotive use of early and effective methods of variable-speed control.

As to electrolysis, which had been held as peculiar to the direct-current system, that such had taken place was not denied, but it was largely due to local conditions, where the tracks were laid in streets filled with sewer, gas, and water pipes. On a trunk line, however, heavy traffic rails of enormous current capacity were carried on wooden sleepers in well-drained broken stone ballast, and they were far from gas and water pipes.

It was not the volume of current on the rail that determined the amount of electrolysis, but the difference and character of potential between different parts of the track. But the single-phase system had a difficulty of its own. With a difference of potential on the tracks of 550 volts, with a maximum of nearly 800 volts, and leaving out the question of electrolysis, which there is good reason for believing will take place, there were serious possibilities of interference with telephone and telegraph circuits.

Comparing the capacity of the New York Central tracks and conductors, the total apparent resistance per mile of the latter will be about six and a half times as much as the former to like volumes of two currents. Thus, if the two roads had sub-stations the same distance apart, with the same loads and line losses, the mean pressures required on an alternating-current system would be over two and a half times those for a direct-current system, and the maximum pressure over three and a half times.

Referring to the use of the third rail, Mr. Sprague said that where traffic is dense, and up to the limits of potential permissible, it has, as now developed, some points of superiority. Of course, where high potentials are necessary, an elevated construction must be used.

Comparing single-phase and direct-current motors, he said that the latter are lighter and more economical, and that for equal draw-bar pull, it would seem that the weight on the drivers of a single-phase locomotive must be much in excess of that required for others, or else when pushed to the limit there will be a periodic slip. A comparison of the New York Central and the New Haven locomotives appears to bear out this contention.

It has been stated that it is not a matter of importance when making infrequent stops, that single-phase motor cars cannot accelerate as rapidly as those equipped with direct-current motors of like capacity. On the New Haven Railroad, however, within the electrified district, the station stops and the schedules are practically the same as those of the New York Subway.

The polyphase motor had but limited possibilities in railway service, and was largely confined to single units. For multiple-unit operation it was ordinarily impracticable because of the small air gaps and the difference of duty with varying wheel diameters.

Compared simply as a machine, the direct-current motor is of simpler construction than the single-phase motor, is lighter and more economical, has a larger air gap and runs at a slower speed. It has from one-half to one-sixth as many sets of brushes, can always have a series winding for the armatures, can be operated at a higher individual potential, and sparking at the commutator can be more readily eliminated.

Heating is less, for the transformer action is absent, and the torque is constant instead of intermittent. The claim that a motor built for successful operation on single-phase currents must necessarily be the best kind of machine for direct-current operation, was not borne out in theory or in practice. If so, there would be no valid excuse for maintaining dual manufacture.

The Atlantic City Convention of the National Electric Light Association

THE twenty-ninth convention of the National Electric Light Association will be held at Atlantic City, N. J., June 5, 6, 7, and 8.

According to Convention Circular No. 1, recently issued by Arthur Williams, chairman of the convention committee, there will probably be not less than eight sessions. These will be held in the small auditorium at the middle of Young's Pier. As the rules of the Atlantic City Hotel Men's Association prevent any single hotel being considered as the association headquarters, Young's Pier has been leased for this purpose during the convention week.

The secretary's headquarters for the registration of members, securing badges, and general information, will be adjacent to the entrance of the Pier. The associates exhibits will be located in the large room at the end of Young's Pier, adjoining the board walk. Between 10,000 and 12,000 square feet are there available, and space may be rented for the entire week at a charge of not over 20 cents per square foot; this charge includes general illumination and everything except the erection of the booth and any special lighting that may be desired. In the plans of the pier distributed to associate members, the exhibition hall has been, for convenience of selection, divided into sections of approximately 100 square feet each. Current required by exhibiting members may be obtained from the local company at 4 cents per kilowatt-hour.

A special exhibit will be made of the various means of advertising employed by central station companies. This exhibit will be under the personal direction of Mr. T. C. Martin, who inaugurated it at Denver last year.

The entertainment features include a reception at the New Marlborough-Blenheim, a trip to Philadelphia by special train, including luncheon at the new Bellevue-Stratford, and a possible convention banquet later in the week. At the front of the pier arrangements have been made for a thousand rocking chairs, and for morning, afternoon, and evening concerts.

The Central Traffic Association and the Southwestern Excursion Bureau have authorized a rate of a fare and one-third from all points in their respective territories to Atlantic City and return for delegates and their friends attending the convention. Special prices have also been obtained from thirty-five hotels, thirteen of which are on the ocean front. The inclusive rates for one person, on the American plan, vary from $2 to $4 daily without bath, and from $3 to $6 with bath; for two persons, from $4 to $8 without bath, and from $6 upward with bath.

In his report to the Indiana State Board of Underwriters, Frank Daniel, electrical inspector, says that the low standard of electrical equipment in that State is due to the lack of knowledge and skill on the part of electrical workers. He found in many cases that the wiring was done by men or boys equipped only with nippers and a screwdriver and a desire to become electricians. More competent electricians are needed. Conditions in Indiana show conclusively that most of the defects in wiring are due to ignorance on the part of local workmen. There is need for more technical knowledge among the electrical inspectors and workmen to bring conditions up to a standard.

Gold From Niagara Falls

By ALTON D. ADAMS

ONTARIO has granted water rights at Niagara Falls for a preliminary consideration of nearly half a million dollars to date, and a maximum yearly rental of about $360,000, and is looking for more. These payments cover the diversion from the upper Niagara River of one-fifth of its nominal and 26.6 per cent. of its minimum flow, but as the Canadian channel carries nearly nine-tenths of the river water, the Horseshoe Falls will continue to present a grand spectacle.

Under these circumstances, is it probable that the governments of Ontario and of Canada will favour a treaty between Great Britain and the United States for the preservation of the American Falls? Against the active opposition of Canada, is it to be expected that Great Britain will force Ontario to forego a large increase of revenue in order to conserve a scenic attraction in the United States that competes with a similar one on the Canadian side?

Unless these questions can be answered in the affirmative, it is probable that the mooted treaty to limit the diversion of water from the upper Niagara River will only maintain a lusty flow down the Canadian channel, while the American Falls go bare.

In negotiations for the preservation of Niagara Falls the United States are at a disadvantage because of the physical conditions there. Just above the head of Goat Island, where Niagara River divides, its waters begin their descent of about 55 feet to the crest of the Horseshoe, and 48 feet to the crest of the American Falls. Across the river, at the head of this island, the total distance is nearly 4800 feet, and of this distance the Canadian channel covers 4100 feet, so that the American channel takes up only about 14 per cent. of the entire width.

Furthermore, while the Canadian channel reaches a depth of more than 20 feet in many places, the maximum depth of water at the head of the American channel is probably not more than one-half of this figure. The result is that about 10 per cent. of the discharge of Lake Erie finds its way over the American Falls. Even this small part of the river water is made less effective for scenic purposes by the fact that the length of the crest line at the falls, 1060 feet, is more than double the width of the American channel at the head of Goat Island, about 2600 feet above.

In contrast with these conditions on the American side, the crest line of the Horseshoe Falls, 3010 feet long, represents only about 74 per cent. of the width of the Canadian channel at the head of Goat Island. From this it may be seen that the Canadian channel acts like a funnel to pile up the water for its plunge at the Horseshoe, while the other channel spreads its discharge like a fan at the American Falls. Lower the water level a few feet where the river divides, above Goat Island, and the appearance of the Horseshoe Falls will not be greatly changed, but the American Falls will disappear.

This brief statement of the facts as to the Niagara River bed shows that the difference in the elevations of that bed on the American and Canadian sides of Goat Island is the key to the situation. Because of the greater elevation of the river bed at the head of the channel to the American Falls a diversion of water that is sufficient to dry up these falls will have comparatively little effect on the great spectacle of the Horseshoe. This fact exposes the inherent weakness of the position of the United States in any negotiations for the international regulation of the diversion of water from Niagara River.

It is desirable that some part of the discharge of Lake Erie be devoted to the production of useful power, and Canada may well contend that any diversion which does not seriously impair the scenic features of the greater cataract, the Horseshoe Falls, is not unreasonable. A plea for the preservation of the American Falls at a loss of several hundred thousand dollars yearly to Canada, is not apt to weigh very heavily with Englishmen.

In reply to a demand of the United States for the preservation of the Falls, it may be said that even when the channel between Goat Island and the New York bank is dried up, a part of the greater cataract will still be within United States territory. The international boundary line, as fixed by the Treaty of Ghent, lays out in the Canadian channel about 1200 feet from the side of Goat Island near its upper end, and cuts the crest of the Horseshoe Falls at a point 480 feet from this island. Another weak point in the position of the United States is due to the great present and greater prospective diversion of water from the Great Lakes and Niagara River within its own territory. Illinois is making a small part of this diversion through the Chicago Drainage Canal, which is expected to draw 10,000 cubic feet of water per second from Lake Michigan when completed.

New York has authorized the other diversions of water on the American side of the Great Lakes and their outlet, and nearly all of these are purely for power purposes. When the new Barge Canal is completed, it is estimated that the section between Buffalo and Savannah will draw 1237 cubic feet of water per second from Lake Erie. At Niagara Falls, one company operating an electric power plant is authorized to divert enough water from the upper river to develop 200,000 horse-power, and already has a plant of more than one-half of this capacity. For the development of the full 200,000 horse-power, under the head at which the present plant is operated, about 17,200 cubic feet of water per second must be diverted from the river.

Another company, with an electric power plant on the New York side of Niagara Falls, takes water from the upper river and discharges it into the Gorge below by means of a canal, with a capacity to deliver 7700 cubic feet per second. Still a third company chartered by New York State has begun work on a hydro-electric development that includes a canal from the upper to the lower Niagara River and a power house in the Gorge. The reported plans of this company call for a present development of 150,000 horse-power capacity, and this will require about 8000 cubic feet of wa-

ter per second under the head that is to be utilized.

In the legislative grant to this last-named company, however, no limit is placed on the rate at which it may divert water from the upper Niagara. There are also several other New York corporations that are authorized to divert water from the upper Niagara River without limit, but have not yet begun to operate. All this is a heavy record for the United States to face in international negotiations. One item is the 11,237 cubic feet of water per second that the drainage and navigation canals of Illinois and New York are to draw from the Great Lakes.

The next count covers the 32,900 cubic feet of water per second that the plants now under construction or in operation on the American side of the Falls will draw from the upper Niagara River, making a total of 44,137 cubic feet of water per second for works now under way. Beyond all this are the unlimited rights of several New York corporations to divert as much water as they will from the same source. With this record before them, with what assurance can the plenipotentiaries of the United States ask that Canada refrain from selling such part of Niagara Falls as the grantees of New York do not take by way of free gift?

But to save the American Falls, the United States must go further than this, and must ask that Canada forego some of the millions of revenue for which it has already contracted, as well as abjure future grants of water rights by which it may obtain additional millions. Will Great Britain force Canada to do this?

If Canada agrees both to forego additions to its revenue from Niagara water and to nullify some part of its existing grants, on condition that the United States take similar action, for the purpose of saving the American Falls, who is to pay the untold millions of dollars in damages to vested interests? Canada is not bound by a written constitution to give compensation when franchises that have become private property are withdrawn, but nobody supposes that the principles of Magna Charta, forced from King John, at Runnymede, nearly seven centuries ago, will be violated in any part of the British Empire.

And so in the United States, the Federal Government is bound by the Fifth Amendment of the Constitution, just as New York is by the Fourteenth, not to take franchises that have become vested as private property without due process of law, which implies compensation. Canada will hardly be willing to forego prospective revenue, or abate present operations at Niagara Falls, unless the United States pay the losses and damages that result. Will the United States consent to pay all damages to private interests for the loss of franchises on both sides of Niagara River, and also to make good the loss of revenue to the Province of Ontario, all of which might amount to tens of millions of dollars, to save the American Falls?

There may be some question as to how far existing water rights on the New York and the Ontario side of Niagara River would have to be revoked in order to allow a moderate flow of water down the American channel. Some light on this point may be got by considering the Canadian grants.

Of the three hydro-electric plants partly completed in Queen Victoria Park, one is to have a capacity of 110,000, another of 200,000, and the third of 250,000 horse-power. For the operation of these plants at full load, the necessary volumes of water will be substantially 10,000, 14,000, and 20,000 cubic feet per second, respectively, a total of 44,000 cubic feet. All this water is to be taken from Niagara River above the Falls, and discharged into the Gorge below. Besides this diversion near the Falls, there is the Welland Canal, which carries water directly from Lake Erie to Lake Ontario, with the surface of the former as its summit level. Though primarily designed for navigation, the Welland Canal is being used also for power development, and the largest electric plant supplied by it has the right to divert 700 cubic feet of water per second.

A moderate estimate of the total draught by this canal on the water of the upper lakes seems to be 2000 cubic feet per second, which brings the volume of water to be diverted from Niagara Falls by the operation of power plants and canals, now completed or under construction in Ontario, up to 46,000 cubic feet per second. As previously noted, the demands of canals and power plants now in operation or under construction in the United States will divert about 44,000 cubic feet of water per second from the Great Lakes and the Niagara River above the Falls. Adding this figure to the 46,000 cubic feet per second, just found for the hydraulic developments in Canada, gives a total of 90,000 cubic feet of water per second that works which are now under way will eventually divert from Niagara Falls.

According to the report of the Secretary of War for 1900, the mean discharge of Niagara River during the twelve months ending with June of that year was 222,400 cubic feet of water per second, and the minimum discharge was 165,340 cubic feet.

The level of Lake Erie, corresponding to this minimum rate of discharge, was 570.25 feet above tide water, and the highest level for the year was 573.12 feet, with a discharge rate of 231,350 cubic feet per second for Niagara River. Of this minimum discharge rate of 165,340 cubic feet per second, the 90,000 cubic feet of water per second which completed and partly completed canals and power plants in the United States and Canada are to divert from the Great Lakes and Niagara River amount to 54.4 per cent., and of the mean discharge rate of 222,400 cubic feet per second this diversion is 44.6 per cent.

It is to be noted that the shrinkage of 66,010 feet in the discharge rate of Lake Erie through the Niagara River corresponds to a fall of only 2.87 feet in the lake level. What, then, must be the discharge rate of that river when the surface of Lake Erie sinks as much as 4.1 feet below its maximum level through causes other than wind pressure, or is forced seven feet below its normal elevation, at the head of Niagara River, by the wind alone, as happens at times?

At Port Day, about one mile above the American Falls, where records of the river level have been made during a number of years, the water elevation has shown a variation of 7.6 feet. From these known fluctuations of lake and river levels, it is evident that the minimum discharge rate of the latter must be much less than 165,340 feet per second above noted. Another fact pointing to the same conclusion is that, while the depth of water at the crest of the American Falls is nearly 4 feet at times of full discharge, there were periods during the winter of 1903-4 when cakes of ice only 18 inches thick caught on the rock shelf of the cataract before going over. In this same winter the flow of water between Goat and Luna islands, at the crest of the American Falls, entirely stopped, and the Cave of the Winds lay bare.

Before the canals and power plants now under way have diverted their full quota of 90,000 cubic feet of water per second, there can hardly be a doubt that the American Falls will entirely disappear, if the river

bed remains unchanged. But even 90,000 cubic feet per second is not the limit of the possible diversion from the Falls, under existing charter rights, for besides the unlimited charters granted by New York State, at least one company on the Canadian side of the river is authorized to take as much water as it pleases from above the cataract.

If present water rights are not utilized to their full extent, it is easy for Ontario to grant others, and there is the great incentive of possible millions in revenue to do so. With 90 per cent. of 222,400 cubic feet of water per second going down the Canadian channel, or 200,160 feet, and only 44,000 feet per second required by the plants under way in Queen Victoria Park, Ontario obviously has a great opportunity to increase its revenue.

Under the existing contracts, these 44,000 cubic feet of water per second are to develop 560,000 horsepower and to yield the Ontario Government an annual income of $360,000. If the grants of water rights are increased up to, say, three times the capacity of the works now under way, or if a like increase be made under existing franchises, Ontario will receive an annual income of $1,080,000 for the use of Niagara River, at the present rates. In return for this income about 132,000 cubic feet of water per second will be diverted from the upper Niagara River, or two-thirds of the volume that goes down the Canadian channel at times of normal flow.

But for the continued diversion of water in Illinois and New York, the scale of 132,000 cubic feet per second by the Ontario authorities would still leave about 68,000 cubic feet of water per second for the Horseshoe Falls, or nearly three times as much water as now goes over the American cataract. When the Canadian plants are sucking down water at this rate, the channel between Goat Island and the New York shore will be bare.

The normal and minimum rates of discharge above stated for Niagara River during the year ending June 30, 1900, were observed when only a trifling volume of water was being diverted from the Great Lakes and their outlet. At that time the only draught of moment on the Great Lakes was that of the Welland Canal, of the Erie Canal, of two electric plants on the New York side of the Falls, and of some small users of water power at the same point. These diversions all amounted to less than 10,000 cubic feet per second. Even now the draught on the chain of lakes, from Chicago to Niagara Falls, is probably less than 25,000 cubic feet per second.

It follows that the canals and power plants now under way will take as much as 80,000 cubic feet per second more water from the lakes and river than was being diverted in 1900, and that little more than one-fourth of this ultimate diversion has yet taken place. From the above facts, it seems clear that there is small hope of saving the American Falls, if reliance must be placed mainly on a treaty with Great Britain for that purpose, because of the untold millions that the United States would be called on to pay.

But, happily, there is another resource. As has been shown in detail in another place, it is entirely practicable to excavate the channel to the American Falls, at and above the head of Goat Island, so that these falls will receive a share of the Niagara water as long as there is any left to go over the Horseshoe. When this has been done, and not until then, the United States will be able to meet Great Britain on an equal footing for the negotiation of a treaty to preserve Niagara Falls.

Transmission Line Voltages

In a presidential address on "The Influence of Electricity on Power Engineering," recently delivered before the Civil and Mechanical Engineers' Society, in England, W. B. Esson, M. Inst. E. E., spoke as follows of transmission line voltages:—

The pressure given by the Niagara generators is not high, nor is the pressure on the lines to Buffalo over which from Niagara 24,000 H. P. is transmitted. Originally the pressure on the Buffalo lines was 11,000 volts, but in 1901 it was raised to 22,000 volts, consequently it does not exceed that of the transmission from Lauffen to Frankfort ten years before. It was not until 1897 that any increase over the Frankfort pressure was made, but in that year the South Californian Power Company transmitted power over 80 miles at 33,000 volts. Several plants were installed at this pressure, and in the meantime experiments were being vigorously prosecuted with the object of finding out whether a still higher voltage could not be successfully employed.

These experiments culminated in the Telluride Company adopting in 1898 a pressure of 40,000 volts for their Provo transmission, and at the present time there are several installations in the States working at this pressure. The Shawinigan Water & Power Company is operating over a line 84 miles long with 53,000 volts. The Washington Power Company, the California Gas & Electric Company, and the Guanajuato Power & Electric Company are all operating at 60,000 volts, while the Kern River Power Company is busy with a line on which the pressure will reach 67,500 volts. This is for the time being the highest pressure in the world, but two companies are making provision for their apparatus to be capable of working at 80,000 volts, so that whenever suitable methods of insulating for this pressure are devised they will be able to adopt it. Lord Kelvin may yet see in actual practice the figure he assumed as a possible voltage at the 1881 British Association meeting. At that date there was no polyphase machinery in existence and no transformer, so 80,000 volts was purely a guess. Nevertheless, we have already passed it in the laboratory, and before long may realize it in practice.

In Europe the pressure on transmission lines does not rule high. The distances are not great, and under these circumstances it is preferred to keep the line pressure down to a figure which is possible to the generator armatures and does not require the use of step-up transformers. At the great hydro-electric stations of Vizzola and Paderno, for example, the pressure is only 11,000 volts and 14,000 volts respectively. On the power lines of the Milano-Verese Railway the pressure is 13,000 volts, while on those of the Valtellina Railway it is 20,000 volts. Lately a power installation for the transmission of 3300 H. P. from Gromo to Nembro through 22 miles of line has been put to work at 40,000 volts, but this is quite exceptional, and stands alone amongst European undertakings.

A most interesting example of a power installation in the Far East is furnished by the Mysore transmission of 4000 H. P. from the Cauvery River Falls to the Kolar goldfield, a distance of 92 miles, at 30,000 volts. The Falls of Foyers, in Scotland, have been utilized by the British Aluminium Company to generate the electricity necessary to their process of aluminium manufacture, but this is not electrical power transmission as we understand it. In North Wales, however, a pioneer hydro-electric transmission installation is

close upon completion. The power is derived from Llydaw, on Snowdon, and there will be transmitted in the first instance 4000 H. P. at 11,000 volts for the working of light railways in the district and for power purposes generally. A scheme which the Scotch Water Power Syndicate have in view is the transmission of 5000 H. P. to the Vale of Leven from a hydro-electric power station 22 miles distant supplied with water from Loch Sloy, which is situated 750 feet or so above Loch Lomond. Here the pressure proposed on the overhead transmission line is 40,000 volts. But the scheme is at present in the air, and whether the conductors will ever get there I would not like to say.

Unless the power transmitted is very large the lower the pressure the better, provided that it is high enough to allow of the transmission being carried out economically. It would be folly to assert that there are no greater risks with the higher pressures, for, as a matter of fact, with pressures of 40,000 to 60,000 volts "the highest intelligence, vigilance, and excellence must be employed to avoid accidents and ensure success." These pressures are not to be used indiscriminately or when they can be avoided.

A large number of plants are operating pressures between 10,000 and 20,000 volts, and of these it may be said that the overhead lines give very little trouble. The latter figure represents a voltage which can be produced in the armatures of machines of moderate size without difficulty.

When we get much above this we enter a zone where we begin to experience the line troubles which very high pressures bring without obtaining all the corresponding advantages they confer. It is very questionable, therefore, whether there should be any halting place between 20,000 and 40,000 volts.

At 33,000 volts Dr. F. A. C. Perrine tells us that the special difficulties due to capacity, insulator size, erratic lightning-arrester effects, and switching begin to make themselves seriously felt, and it is just as well if we have to redesign the apparatus with special reference to these difficulties, that we may carry the pressure to the other extreme of the zone referred to, and so get the full return for our trouble. If high pressures are ever standardized, the figures for the standards will be probably 20, 40, 60, and 80 kilovolts.

With pressures of the order of 40,000 volts quite a new set of phenomena is brought to our notice. In the first place, the insulators, in order to prevent flashing over to the supports, must be very much larger, and an increase of pressure from 20,000 to 40,000 volts necessitates their diameter being increased by 50 per cent. or more. A usual size of insulator for the former pressure is 6-inch diameter, while the latter should not be less than from 9 inch to 10 inch, with the addition of at least one intermediate bell between the outside dome and the inside cup.

When these high pressures are used, the phenomenon of brush discharge has to be provided against. This results from the break-down of the air as an insulator owing to electrostatic strain set up in the space between the wires, and it was very thoroughly investigated by several leading engineers in America in 1893. Their experiments showed that while the loss of power due to this cause at 40,000 to 50,000 volts was, with the usual line construction, inconsiderable, after the higher figure was reached the loss increased rapidly. Prof. Ayrton has lately worked out the distance wires of different diameters have to be placed apart to ensure that with certain pressures there shall be no brush discharge. The cure of the evil, of course, is to keep the wires far enough apart and keep them large enough in diameter, for it is common knowledge that in the vicinity of a sharp point or a sharp edge, less pressure is required to break the air down than in the vicinity of a knob or well-rounded edge. A thin wire presents along its whole length a comparatively sharp edge, and while with wires of 1-10-inch diameter, 40,000 volts will discharge through about 10 feet, if the wire is 1-5-inch diameter, discharge will only take place when the distance between the wires has been reduced to 15 inches. As it is usual to space the wires on a 40,000-volt line about 48 inches apart, and as in no lines requiring such high-transmission voltage are wires likely to be less than ¼-inch in diameter, it will be seen that there need be no loss from this cause, but there is enough trouble with switches, lightning arresters, and higher pressure surges in the line without brush discharge.

It is not the high pressure that makes the trouble last mentioned; indeed, raising the pressure reduces surging, since the current is reduced with the increased pressure. Experience has shown that if a large amount of power is transmitted, it is easier to operate lines at a pressure of 60,000 volts than at a pressure of 30,000 volts, because in the former case the current flowing is only about half. Suppose we are transmitting 5000 H. P. to a distance of 50 miles at 30,000 volts. Roughly, the current in each wire will be 80 amperes, and it is possible that if this be suddenly interrupted the surge pressure would rise to 20,000 volts. If it happened that the line was momentarily short-circuited by a lightning discharge, and that during the short four times the working passed, the surge voltage on the removal of this short circuit might rise to 60,000 volts, which pressure would be superposed on the pressure.

With 30,000 volts between the conductors, the pressure between any conductor and earth is 17,300 volts, so in this case the surge voltage makes the possible nearly four and a half times the working pressure. If we worked at 60,000 volts, however, the rise on breaking the short circuit would only be 30,000 volts, and this superposed on the working voltage gives a possible pressure of rather less than twice the working pressure. The momentary strain which insulators, transformers, and other apparatus should be capable of standing is in the case of the 30,000-volt transmission 77,300 volts, while in the 60,000-volt transmission it is 64,400 volts. The higher working pressure has therefore the advantage, and if the power transmitted were increased, the advantage would be more pronounced. It is probable that on account of this rise in pressure due to circumstancs the occurrence of which the greatest precaution will not always prevent, the current to be transmitted through each wire of long-distance transmission lines will not, as a general rule, exceed 100 amperes.

There is no hard-and-fast rule for pressures to be used, but 1000 volts per mile is recognized as good practice. This is subject to limitation, on the one hand, by the highest pressure of which we have commercial experience, and, on the other hand, by the condition that the current in any wire shall not be excessive—a point which has just been dealt with. According to C. F. Scott, a distance in miles equal to three times the number of thousands of volts may be covered without incurring an excessive annual charge per horse-power for copper. This means that 5000 volts would cover 15 miles, 10,000 volts 30 miles, and 20,000 volts 60 miles. That 10,000 volts has reached 28 miles, and 30,000 volts 92 miles is shown by the installations at work. But the solution to all engineering problems lies in compromising, and the pressure is eventually settled by striking a balance between the cost and the risks undertaken.

The Electric Automobile

By HIRAM PERCY MAXIM

Continued from the March Number

FIG. 19.—AN ELECTRIC VEHICLE BUILT BY THE BAKER MOTOR VEHICLE COMPANY, CLEVELAND, OHIO

THE first section of this article, in the March number of THE ELECTRICAL AGE, showed the ground that had been covered in the development of the electric automobile up to a couple of years ago. Nothing was spared to make it better and keep it ahead of its competitors, and the best engineering talent of the greatest industries came finally to assist it. Now, let us see where it stands to-day.

In the pleasure class, examples of which are shown in Figs. 19, 24, 28, 31, 38 and 39, we find the most striking feature, which all electrics seem to possess, is smoothness and quietness of running. In some individual cases an absolute suppression of noise has been accomplished. This, together with gradual increases in speed up to 20 miles an hour, and in the very recent types to 25 miles an hour, actually causes a vehicle to give the effect of being unreal. The nearest thing comparable with it seems to be flying, and to the passenger in such vehicles the sensation is the very perfection of locomotion.

As already stated, the speeds have increased so that 15 to 18 miles an hour may be given as a standard for every type of pleasure vehicle. The latest broughams, victorias, hansoms and similar large vehicles go 18 to 20 miles per hour on a level street with a full load of passengers. The average runabout makes 15 to 18 miles, while several make 20, and some 25 miles an hour on the level on the last notch.

Furthermore, the mileage of these vehicles has been increased, and 40 service miles on one charge may be taken as a minimum of a modern electric carriage. Under favorable conditions a distance of 50 miles is possible, and several makers claim 60, and even 75 miles on a single charge for the smaller classes of runabouts and phaetons. This can probably be done under favourable conditions only, however.

It is interesting to analyze the causes of these greater speeds and mileages, for the storage battery has not improved in capacity per pound in proportion, nor has the efficiency of the electric motor yet passed 100 per cent! The principal reasons are the reduction of bearing and tire losses. In the case of the former, mechanical design has improved in the direction of flexibility. Members difficult to maintain in alignment are no longer kept in line. Ball and roller bearings have been adopted freely on all parts from armature shafts to wheel hubs.

FIG. 20.—AN EXPRESS WAGON BUILT BY THE CHAMPION WAGON COMPANY, OWEGO, N. Y.

FIG. 21.—A "SEEING-NEW-YORK" CAR BUILT BY THE ELECTRIC VEHICLE COMPANY, HARTFORD, CONN.

In the case of tires, a still greater saving has been effected. It has been found that on pneumatic tires of cord and thread fabrics, the losses in the tire itself are about 50 per cent. less than in tires of the ordinary fabric, such as are commonly used on gasoline automobiles. This saving made a direct reduction in the tractive effort, and assisted materially in obtaining the higher speeds and longer mileages.

Another feature which has assisted is the reduction in weights of the vehicle proper, which have been effected lately in consequence of having available better and more specially suitable materials. Pressed steel frames, nickle and chrome-nickle steel, and fairly strong aluminum are all available now, where five years ago composite plate steel, wood frames, machinery steel, and malleable iron were the corresponding equivalents.

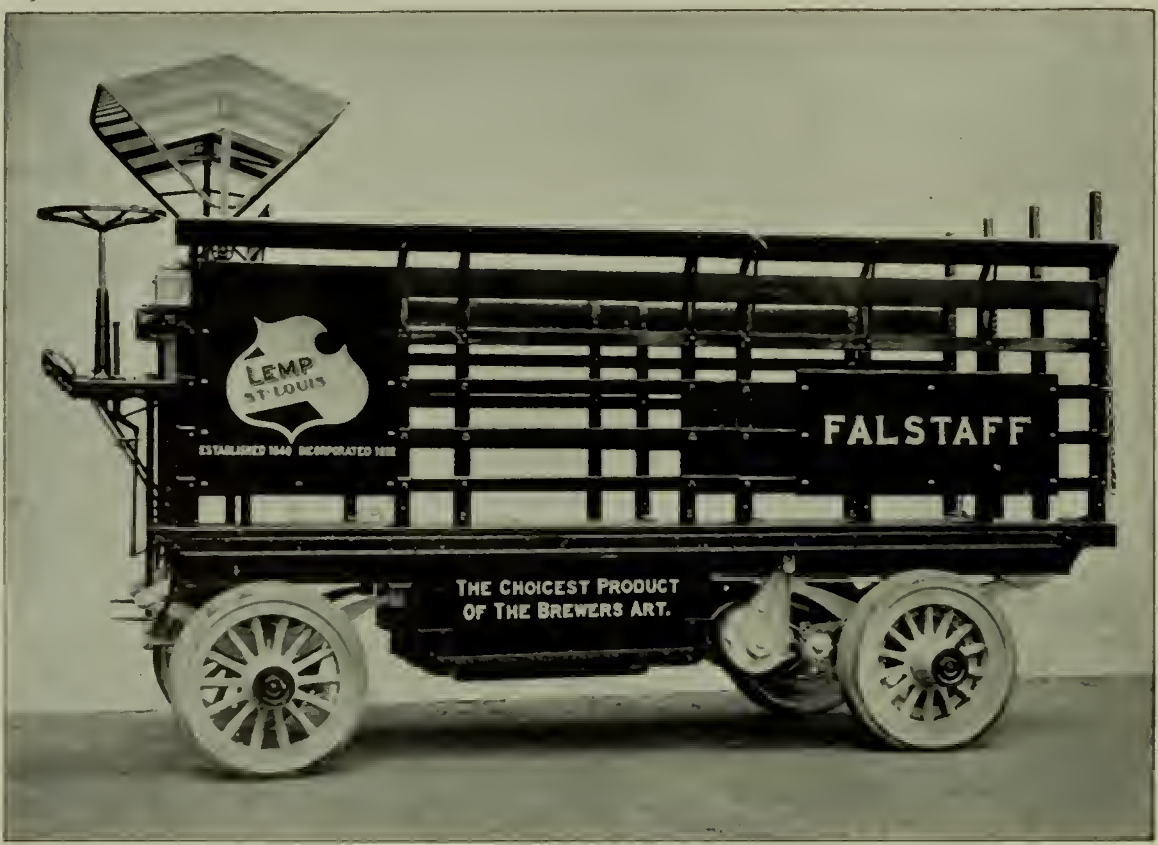


FIG. 22.—A 5-TON ELECTRIC TRUCK BUILT BY THE ELECTRIC VEHICLE COMPANY

Another feature is the herring-bone gear, with which tooth speeds two to three times higher are possible than were permissible with the spur-gear tooth. This means that higher speed electric motors were possible, which effected a saving in weight at once. To-day motors of 2000 revolutions per minute, and over, are common practice, where 850 was the practical limit six years ago.

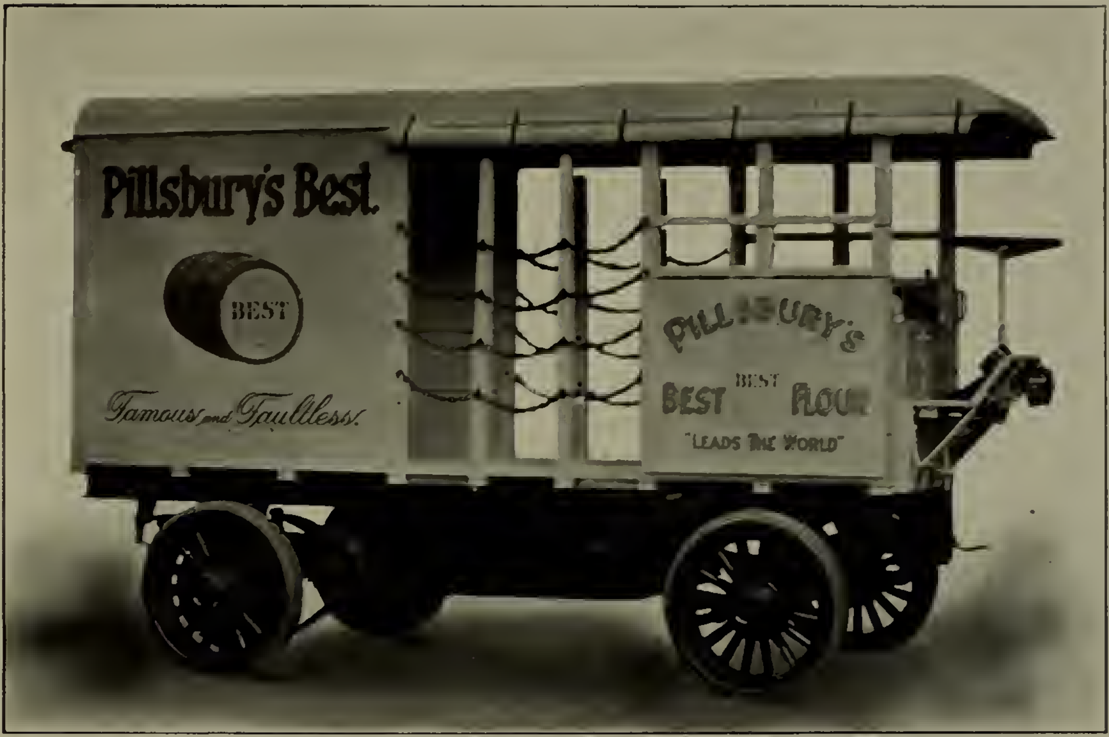
In motors and control, important improvements also have been made. Where the straight series-field motors were formally universal, and the speeds were obtained by dividing up the batteries, and opening the circuit completely between each controller notch, we now have motors with "overwound" fields, and controllers which not only gradually reduce these fields without shock or jar, but also actually slip from the series to the multiple position without opening the circuit or permitting the driving torque to fall off. Wonderfully smooth acceleration is thus obtained without subdivision of the batteries at all.

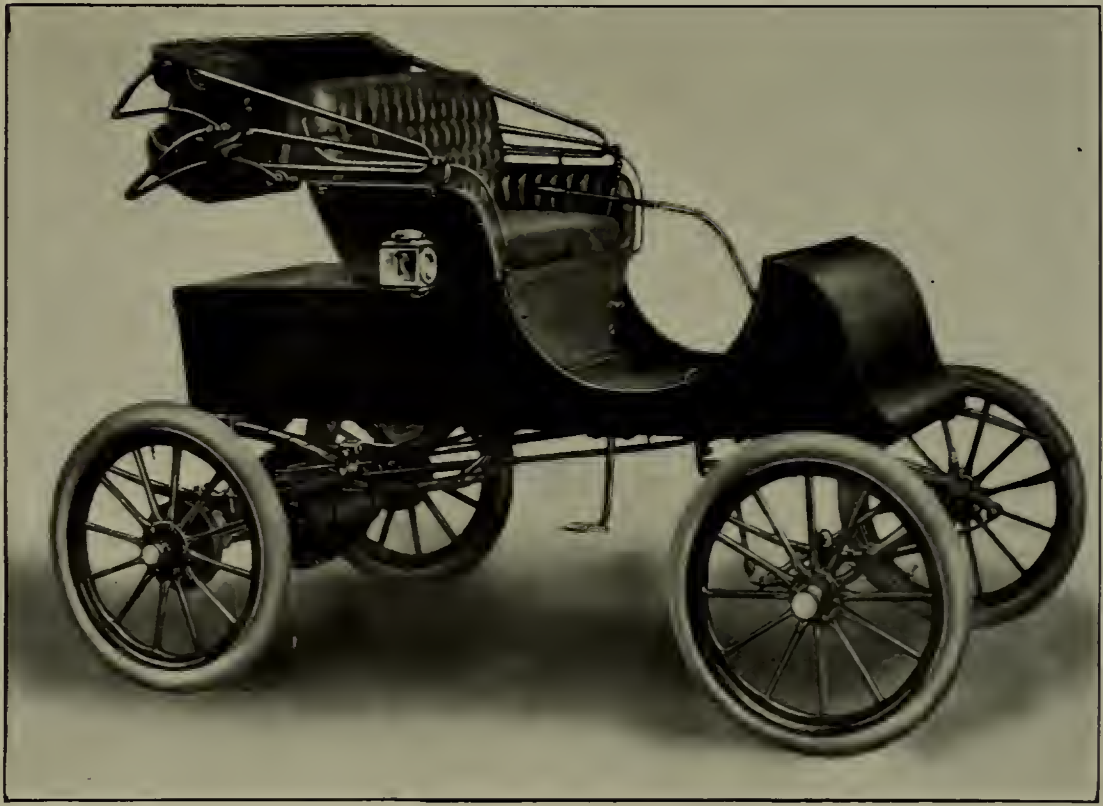
One of the alternative forms of motors has a compound field. The shunt-field winding is used to augment or reduce the series field, and so accomplish the equivalent result of gradually cutting in or out the overwound field. Another refinement to help the electric along is the use of a single motor instead of two motors. This of course makes a large motor, in which better electrical characteristics are possible than would be the case in two smaller motors. A reduction in weight is also made possible, together with a reduction in the cost of manufacture.

A single motor requires a compensating gear, which is usually placed in the rear axle and requires a divided driving shaft. In the vehicle of ten years ago this was the construction frequently used, but trouble in the compensating gears and weakness in the divided axle caused it to be given up for the two-motor arrangement, which made possible the suppression of the compensating gear entirely. The development of a successful compensating gear and a rear axle construction which was not weak, has now changed this about, and we find ourselves back again to the old arrangement of single motor.

Let us now consider the storage battery, the determining factor after all, no matter how we may develop everything else. Except for the advent of the Edison battery, but very little change has occurred in the battery during the last two years. The ampere-hour capacity per pound remains just where it was then, namely, approximately 3.9. The field is still held by the lead-lead cell, which to some is disappointing. Something startling has been looked for by the general public in storage battery invention for five years past, but it has not materialized. All that can be said is, that the details of the old style lead storage battery have been refined and made serviceable and somewhat lower in price. The mechanical parts of the vehicle have been developed along parallel lines with the battery until the whole is well harmonized, and general information about storage batteries has been disseminated until skilled attendance is easily obtainable at fair prices. This is all that can be said. The limits of materials known today seem to have been reached.

In the case of the Edison battery, the original idea was to secure indefinite length of life, high charging rate and increased capacity per pound. Bulk and first cost were left as secondary conditions. Just how far the battery has attained these aims is in doubt. It is known, however, that in theory it should have the long life, and practice seems to indicate that its capacity per pound is an improvement over the lead cell. Its bulk is greater than the lead per unit of capacity, which is against it under some conditions, and its first cost is higher. While it has been used to a considerable extent, it is not by any means common practice, especially in the pleasure-carriage field. It has probably a good future ahead of it, provided no other battery appears which is enough cheaper to offset its promised long life.

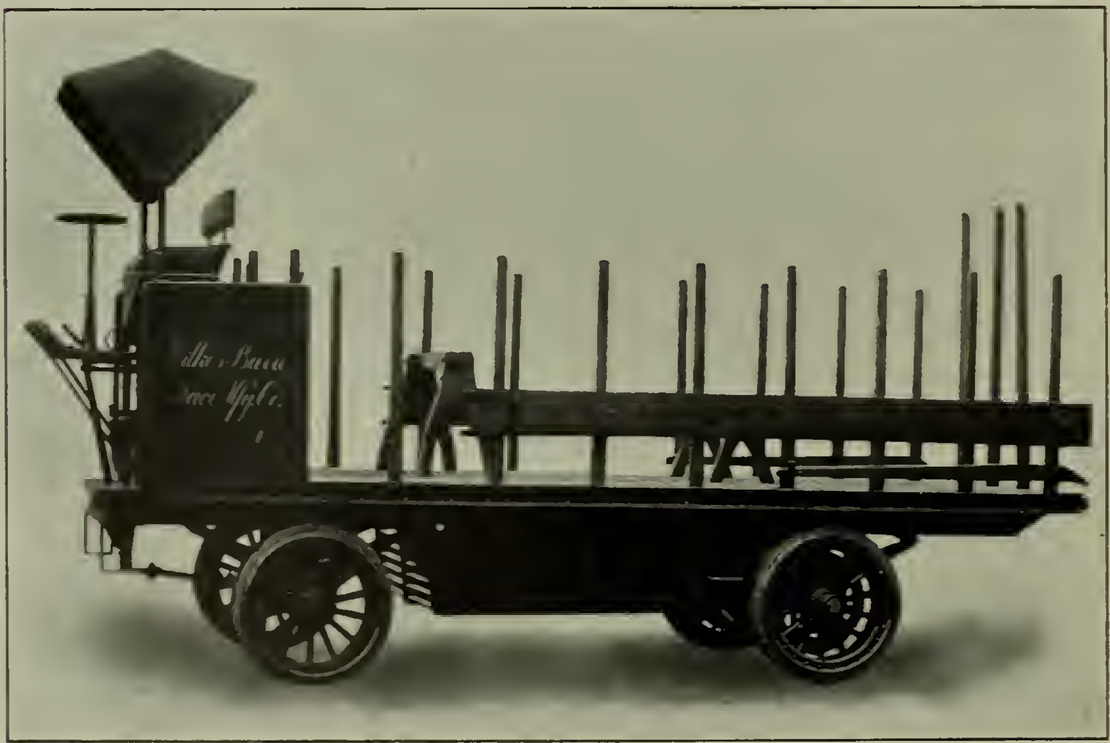




FIGS. 23 AND 24.—A POPE-WAVERLY 5-TON ELECTRIC TRUCK AND RUNABOUT BUILT BY THE POPE MOTOR CAR COMPANY, INDIANAPOLIS, IND.

A few words should be said here about the modern commercial electric vehicle. One of the most striking departures from previous practice is the tendency toward suspension of everything possible above the springs, and also the use of a single large motor instead of two smaller ones. The latter has not, however, yet become usual among builders generally, while the former construction is most frequently found.

Where the old types of wagon had their motors pivoted from the rear axle, as Morris & Salom had originally, or else mounted rigidly upon the reaches or perches of a running gear, the modern tendency seems to be toward mounting the motors upon the body or chassis frame, where they have the benefits of housing in and spring suspension. The power is transmitted from the motors to the driving wheels by chains, this construction being con-



FIGS. 25, 26 AND 27.—TYPES OF MODERN PINION AND GEAR-DRIVEN ELECTRIC VEHICLES BUILT BY THE VEHICLE EQUIPMENT COMPANY, NEW YORK

sidered easier for the motor and also easier for the axles and tires, as well as cheaper to maintain. The writer introduced this construction while collaborating with the Studebaker Bros., in South Bend, Ind. An interesting illustration of the first vehicle equipped thus is given in Fig. 30. The vehicle was an open express wagon with wheels of large diameter and iron tires. The batteries were carried beneath the body between the axles, and the wheel base was made as short as possible. The motors were carried back of the rear axle and they and their countershaft and first reduction gears were integral. Chains led forward to the driving wheels. Everything was above the springs but the axles and wheels themselves.

In the illustration, J. M. Studebaker, the only surviving one of the famous brothers, is seated in the front seat beside the writer, who has the steering wheel. The various heads of departments of the Studebaker Co. occupy the rear seats. Col. George Studebaker, of the younger generation, being nearest on the rear seat. As an example of the entrance into the motor-vehicle field of the greatest vehicle builders in the world, this, their first motor wagon on its first trial trip, has considerable historical interest. It was produced early in 1902, and marked the beginning of the introduction of the chain-driven electric wagon.

The later development of this construction is shown in Figs. 20 to 23, and also in Figs. 29 and 32, illustrating the wagons and trucks of the Studebaker Co., the Champion Wagon Co., the Electric Vehicle Co., and the Pope Manufacturing Co. In all these the motors are carried above the springs, and the drive is by chain. No running gear is used, the axles being located solely by the springs in the sizes below two tons capacity, and by distance rods in sizes above two tons. Cheapness of construction, simplicity, and low maintenance expense are at their best.

Another type of construction which has enjoyed very wide use is that of the Vehicle Equipment Co., of New York, the largest builders of electric commercial vehicles at the present time. Figs. 25, 26 and 27 show some of their work. The axles are located longitudinally by pedestals, as in car construction, and ordinary full elliptic or half springs are used. The motors are pivoted from the axles as in the original Morris & Salom models, the forward ends only being carried from the bodies. Pinion and gear drive is used.

Another general feature of devel-

FIG. 28.—A "COLUMBIA" ELECTRIC AUTOMOBILE BUILT BY THE ELECTRIC VEHICLE COMPANY, HARTFORD

opment in the wagon line has been the adoption of the self-contained chassis construction, after the manner of gasoline cars. This chassis constitutes every operated part. All wiring, control, steering, braking and detail features are assembled on this frame, which is really a complete vehicle without the body. A standard chassis is thus able to take any special body that may be desired. In its effect upon cheapening and standardizing manufacture, this development has been of great assistance.

Whether or not it is destined to remain a permanent feature of construction is becoming questionable, however, since the tendency in recent developments is toward standard parts, now purchasable from large parts builders. They may be easily attached to any type of body, the parts builders having developed a very complete line of all the necessary parts for all sizes of wagons. The advantages of standardization are thus obtainable without the necessity of a self-contained chassis. After all, the springs, battery, motors, and braking and steering gear can as well be attached to the bed of a wagon body as to a chassis frame. Leaving out the chassis frame, moreover, effects a saving of both weight and expense. Illustrations of parts furnished by the most prominent parts builder, Hayden Eames, of Cleveland, Ohio, are shown in Figs.

FIG. 29.—A 3-TON TRUCK BUILT BY STUDEBAKER BROS. MANUFACTURING COMPANY, SOUTH BEND, IND.

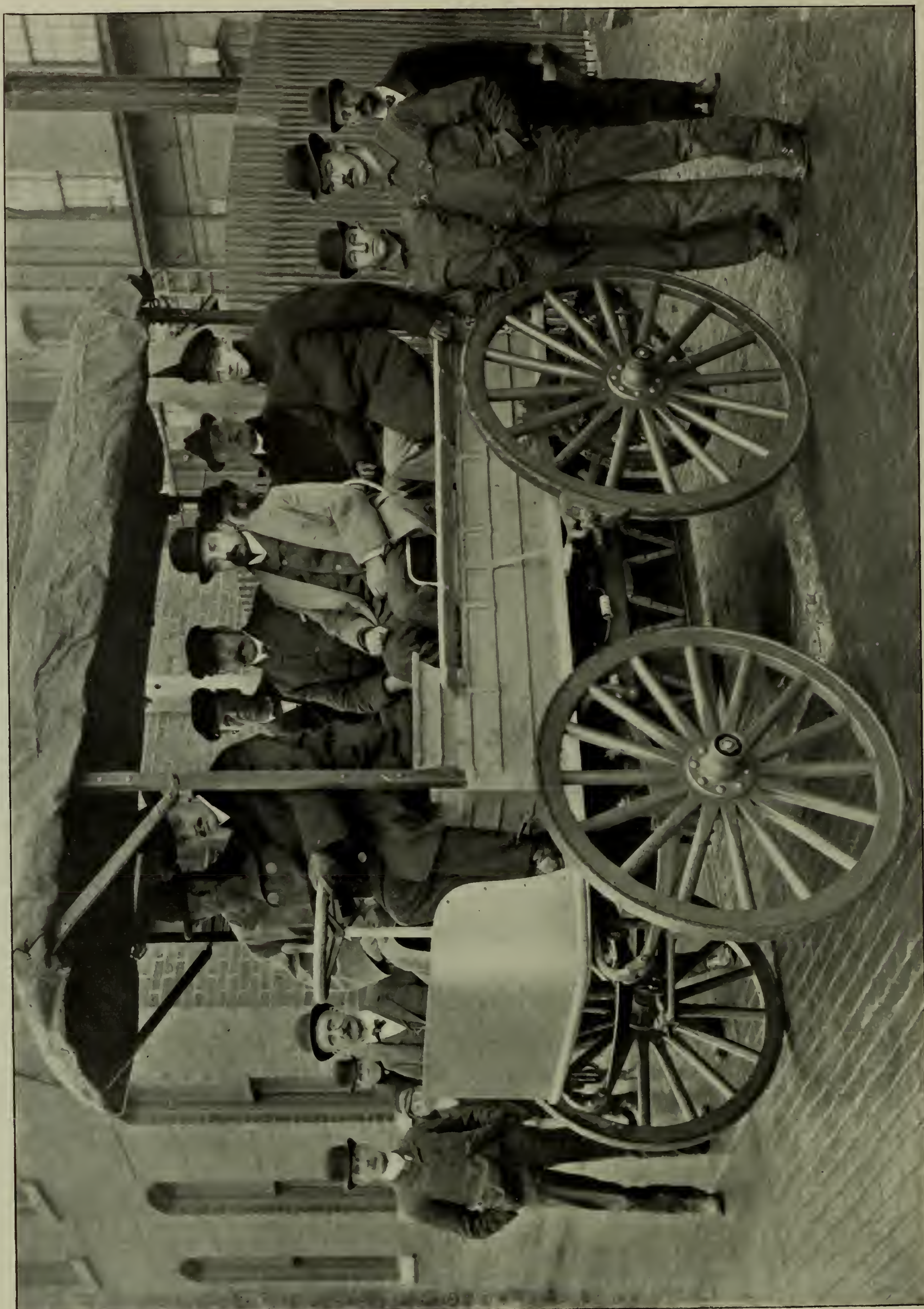


FIG. 30.—THE FIRST OF THE PRESENT CLASS OF CHAIN-DRIVEN ELECTRIC TRUCKS. THIS WAS THE FIRST MOTOR VEHICLE TO BE BUILT BY THE STUDEBAKER BROS. MANUFACTURING COMPANY, OF SOUTH BEND, IND.

33, 36 and 37, on pages 264 and 265.

When we come to the battery of the electric commercial vehicle we find nearly the same conditions regarding development as we have in the pleasure carriage. Capacity per pound has not improved to any great extent, nor has first cost been materially reduced. Improvement has been principally in more durable plates and detail construction.

Until within a year the pasted type of plate has been the one principally used. Except for details in mud-space cellar, separators, and connecting straps, it has been identical with the pleasure carriage battery. Within the year, however, the Electric Storage Battery Co. has brought out a so-called "truck" type of battery, in which the positive plates are of the Planté type. No extended experience with a large number of vehicles for a considerable time has yet been had, so that a comparison with the old plate is not possible. There would seem to be every reason for expecting a longer life, however, which means lower maintenance expense per vehicle-mile.

FIG. 31.—ANOTHER "COLUMBIA" ELECTRIC PLEASURE CARRIAGE

In the case of the Edison battery, the same battery is used for trucks and wagons as for pleasure carriages, so that what has been said about the carriages applies also to the wagons.

In the main, the mileage and speeds of wagons and trucks have not been increased to any great extent since the early days. A wagon or truck should do a full day's work on one charge. In ordinary service this means 30 to 35 miles for a half-ton and a ton wagon, 30 miles for two and three-ton trucks, and 25 miles for five-ton trucks. These mileages are obtainable in all makes of modern electric trucks. The full-load speeds which have come to be usual are, 12 miles an hour for half-ton wagons, 10 to 12 for one-ton wagons, 8 to 9 for three-ton trucks, and 6 miles for five-ton trucks. These speeds and the superior control and flexibility of the motor vehicle, usually result in accomplishing from 150 to 250 per cent. more in tonnage and mileage than is possible with horse service.

On the score of cost of operation, it is very difficult to give comparative figures which are at all exact for electric and horse-truck service. Furthermore, there is more in the question, frequently, than that of cost. Convenience, despatch, and flexibility have a value which is impossible to express in many instances. When it comes to cost alone, however, and when it is possible to accurately get the real cost of horse service, that of the modern electric in competent hands has been found to be less, in an amount depending almost entirely upon the competence of the attendance.

Some of the subsidiary features in the development of electrical automobile apparatus are worthy of note, one of the most far reaching in its effect being the mercury-arc rectifier. For a long time the electric automobile could not be charged in many places where current was available, because this current was alternating. There is no doubt that this held back introduction to a considerable extent. When the mercury-vapour incandescent lamp appeared a few years ago, one of the peculiar properties of the lamp was found to be the annulling of one of the alternations of an alternating circuit. Quickly the possibilities of a simple rectifier were grasped. Special developments began at once, resulting at the present time in both the Westinghouse Electric & Manufacturing Co., and the General Electric Co. standardizing and placing regular lines of automobile charging rectifiers on the market. Wherever current is present, then, the electric automobile can now be charged,—an important feature.

Another detail development of importance is the wood tire. Owing to the cost of rubber and its rapid wear, an effort has been made for some years by several manufactures to produce a substitute, especially for wagons and trucks. Soft iron, steel, composite steel and iron, iron and lead, rubber, fabric, and wood were

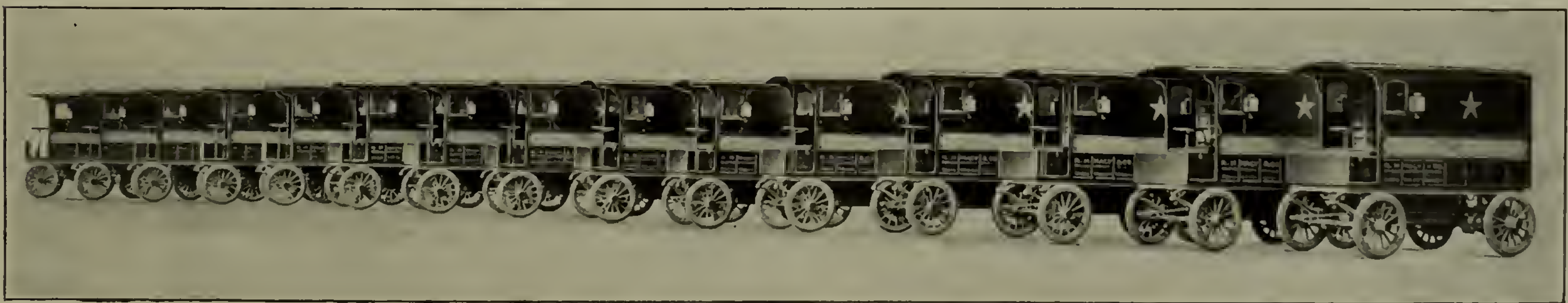


FIG. 32.—ELECTRIC DELIVERY WAGONS BUILT BY THE ELECTRIC VEHICLE COMPANY, HARTFORD, FOR R. H. MACY & COMPANY, NEW YORK

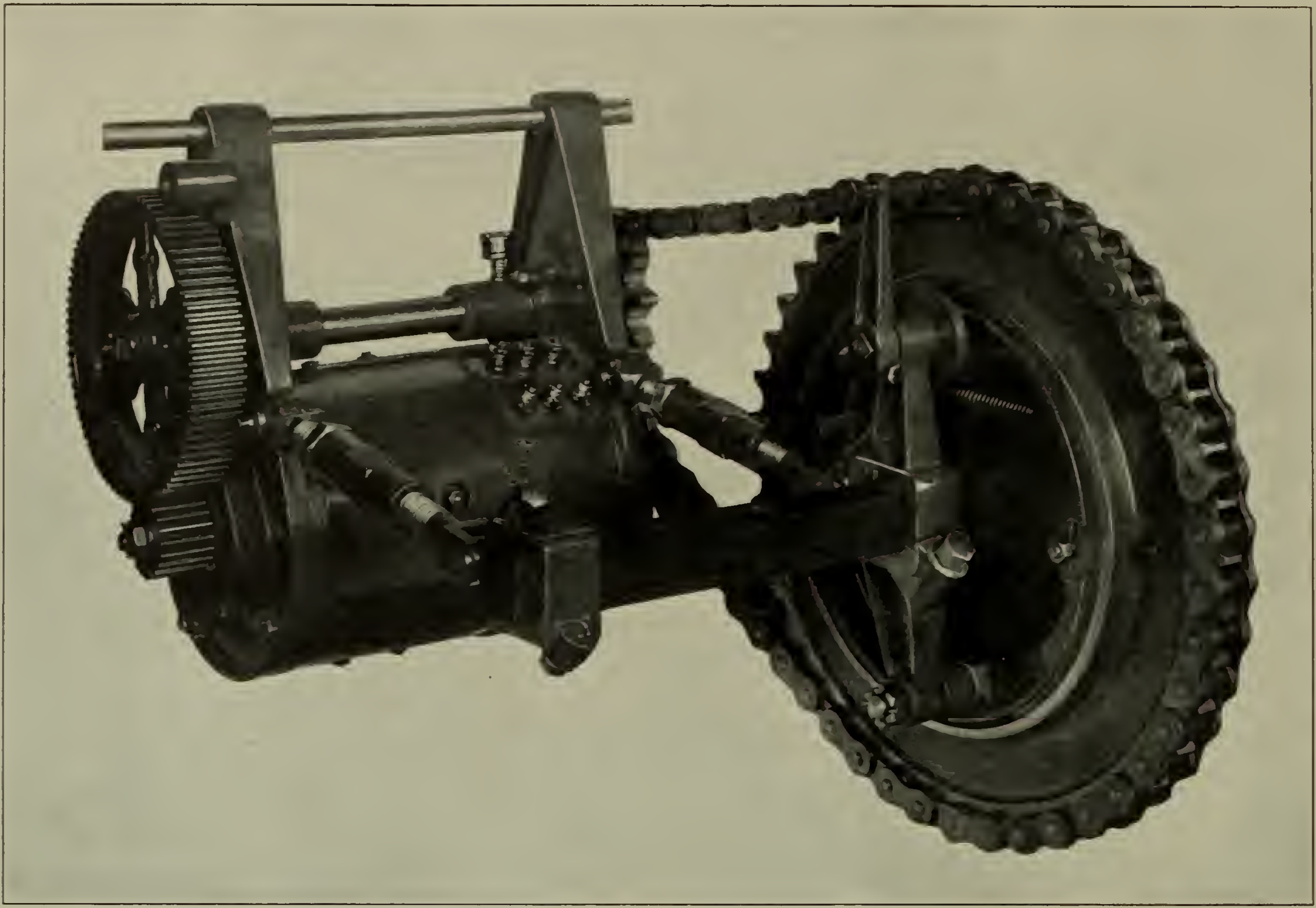


FIG. 33.—A COMPLETE MOTOR EQUIPMENT BUILT BY HAYDEN EAMES, CLEVELAND, OHIO, FOR ONE SIDE OF A 5-TON TRUCK

all tried. The most practical substitute to date has been the wood tire, consisting of a series of segmental blocks of wood arranged around the periphery of the wheel, with the end grain out, and securely fastened in place between flanges. In service, while heavy and somewhat clumsy in appearance, the tire has proved fairly practical. It does not strike a sharp, inelastic hammer blow, as does iron or steel, but instead acts like a wooden mallet. It is about half way between rubber and iron in point of noise. On ordinary surfaces it gives very satisfactory traction, but on ice it slips quite badly and requires sand or some traction strap device.

Another development, also in the line of improving traction, is the four-wheel drive. In several experimental vehicles that have appeared, all four wheels have been connected up as drivers. In some cases, four separate motors, and in others, one or two motors, have been used with mechanical transmission. Improved traction has been attained, but the added complication and losses have, up to the present, prevented the arrangement from coming into general use.

This covers, roughly, the record to date of the electrically-propelled vehicle. We have seen it improve in certainty, quietness of running, and smoothness of control, until it has become everything that could be desired in these particulars. Up to recent times we have seen its superiority in these points absolutely bar the gasoline or steam machine from entering its field.

But within a year a change has come. The gasoline machine has ar-

FIG. 34.—A MOTOR BUILT BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., FOR USE IN AUTOMOBILES

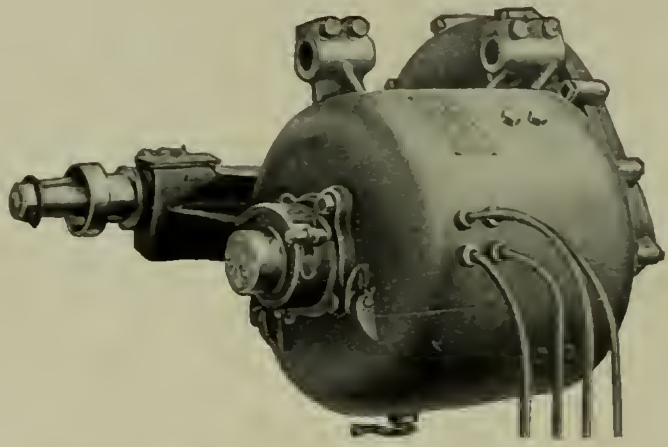


FIG. 35.—ANOTHER AUTOMOBILE MOTOR BUILT BY THE GENERAL ELECTRIC COMPANY

rived at a degree of reliability, quietness of running, and smoothness of control, which, with its advantages of speed and mileage, have brought it at a bound on an equality with the electric. In New York City, the number of gasoline closed vehicles of the brougham class has risen from an insignificant minority to but little short of an equality with the electric.

FIG. 36.—STEERING GEAR FOR A MOTOR TRUCK BUILT BY HAYDEN EAMES

One is led to wonder if another year will see it in the majority.

It must not be understood by this that the electric machine has fallen off this year as compared with past years. On the contrary, the number built has exceeded by a healthy increase the number built in previous seasons. The significant fact is that the electric machine is not increasing in the same proportion as the gasoline machine is, in the field that was once solely occupied by the former.

FIG. 37.—ANOTHER VIEW OF THE MOTOR SHOWN IN FIG. 33

The advantage which the gasoline city carriage has, lies in the fact that, in addition to its unlimited speed and mileage possibilities, its up-keep expense can be made very low, where a good machine is assumed and skillful attendance given. The writer knows of instances where the cost of repairs and renewals, barring tires, has been for two years inside of $50. These same vehicles should, moreover, run for several years more with very low up-keep expense.

Another advantage over the electric is the very low power cost, and that it promises to be much lower is another point, since vegetable alcohol and other substitutes for gasoline are all under development at the present time.

FIG. 38.—A POPE-WAVERLY ELECTRIC PLEASURE CARRIAGE

FIG. 39.—ANOTHER EXAMPLE OF THE PRODUCT OF THE BAKER MOTOR VEHICLE COMPANY

On the other hand, the electric automobile is, as it was in the beginning, still dependent upon something which is inherently expensive, of short life and limited capacity. In spite of the mechanical improvements made in the past two years, it is to-day still faced with its original limitations. The only improvements in principle we are offered for the future seem to be those held out by the Edison battery, or else a very much cheaper lead battery than we know of to-day.

The generally accepted standard battery of to-day is the lead "Exide," made by the Electric Storage Battery Co., of Philadelphia. Compared with any other storage battery it is acknowledged the superior. But this is not enough. While better than anything else to date, it is relatively still high in price, limited in life and moderate in capacity per pound.

It is the present hope to make the Edison battery of long life and slightly greater capacity per pound, at the expense of a higher price. If life can be increased indefinitely, as is claimed, the high price might be shorn of its disadvantages, and the electric automobile helped upon its way considerably. But this is as yet not entirely demonstrated as possible, and even if it were, we would still be confronted with limited mileage capacity, and the high power cost of this particular battery, due to its low recharging efficiency.

Besides the Edison battery, the very cheap lead cell is one other hope that has been extended from time to time. Instead of long life and moderate capacity per pound, it aims at a short life and a somewhat increased capacity, but a very low price. Renewals are intended to be so cheap that limited life will be more than compensated for. This is purely a promise of the future, however. The price of such a battery would have to be reduced very much below what it is now to be cheap enough to enable the electric vehicle to hold its own with those of other motive powers.

As a matter of fact, what is really needed by the electric vehicle is something revolutionary. Either the capacity of batteries must be greatly increased beyond anything we now consider possible, or else some system of direct-current generation must be developed. In the case of the former, it would seem that new discoveries are necessary, since every

combination of every known material seems to have been tried.

In the case of direct generation of current, it is interesting to speculate upon its possibilities. If we take the regulation oxides of lead now used in our battery plates, or the iron and nickle oxides of Mr. Edison, we find that an amount easy of transportation would have more than ample electrical capacity, if it could be gotten out. At present the amount we carry is what can be pasted into the interstices of a latticed lead grid, and we use only a small portion of it at that, on any one discharge. If we could but bring this material into a proper electrochemical contact and enable it to give up its energy, by some continuous feeding process, we would have something which would compare with the other power-generating apparatus of the times.

Recharging such a system ought to consist in simply taking on board a fresh supply of active material. The used material could be left behind to be re-oxidized electrically later on, when most convenient. Carried to a point, it is conceivable that electric central stations could accept such material in part payment for recharged material.

To the writer, whose tendencies ought to be unprejudiced, since he is identified in the development of both the electric and the gasoline vehicle, it seems quite plain that the future of the electric automobile from now on will depend largely upon what our electrochemists are able to do for us. In view of the great possibilities ahead in the internal combustion engine, it certainly appears as though the electric automobile is to suffer in the competition of the future, unless we can improve our current source in some such manner as has been described.

An International Exposition at Tourcoing, France

AN international exposition will be held at Tourcoing, France, from May to September. Among other things, the processes, products, and machinery for textile, mechanical, and electrical industries will be exhibited. The district included in the cities of Tourcoing, Roubaix, and Lille is the most important textile manufacturing district in France. Henry G. Bayer, 47 Barclay street, New York, is special commissioner for the American section.

The New Jersey Legislature has passed a bill permitting trolley companies to carry freight.

Annual Convention of the American Electrochemical Society

THE annual convention of the American Electrochemical Society is to be held at Ithaca, N. Y., from May 1 to 3. The forenoon will be devoted to the reading and discussion of papers. On Tuesday afternoon an inspection will be made of the chemical, electrical, and engineering laboratories and the shops of Cornell University. In the evening the retiring president will deliver an address. On Wednesday afternoon a visit will be made to the Ithaca Gun Company, followed by a banquet in the evening. On Thursday afternoon the members will visit the Remington Salt Company, and perhaps the Morse chain works.

The list of papers to be read follows:—

"The Extraction of Sodium," by C. F. Carrier, Jr.

"Electrolysis," by Maximilian Toch.

"The Effect of Oxides on the Adhesiveness of Electrodeposited Metals," by John Nelson.

"An Instructive Laboratory Experiment in Applied Electrochemistry," by W. H. Walker.

"Impurities in Electrolytic Copper," by F. F. Colcord.

"Electro-Galvanizing," by A. Van Winkle.

"Standard Cells," by G. A. Hulett.

"Lecture-Room Switchboard," by W. D. Bancroft.

"Alternating-Current Electrolysis with Cadmium Electrodes," by G. R. White.

"Ferromanganese Anodes in Caustic Potash," by G. R. White.

"Electrolytic Corrosion of Copper-Tin Alloys," by B. E. Curry.

"On the Physical Properties of Fused Magnesium Oxide," by H. M. Goodwin and R. D. Mailey.

"Differences of Potential Between Manganese and Lead Peroxides and Various Aqueous and Non-Aqueous Solutions," by L. Kahlenberg and A. S. McDaniel.

"Observations on the Corrosion of Iron by Acids," by C. F. Burgess and S. G. Engle.

"The Movement of Suspended Clay and other Similar Particles Under the Influence of the Current," by F. K. Cameron.

"Electrometric Experiments with Reference to the Dissociation of Fused Salts," by H. M. Goodwin and H. A. Wentworth.

"Cadmium Standard Cell," by G. A. Hulett.

"The Development of the Nickel-plating Industry," by Isaac Adams.

"Cathodic Disintegration of Carbon in Electrolyte of Fused Chloride," by G. L. Kemmerer.

"The Electric Vacuum Furnace," by W. C. Arsem.

"The Reduction of Metal Sulphides," by O. W. Brown.

"A New Silicide of Molybdenum," by O. P. Watts.

"A Microscopic Study of Electro-Deposits," by C. F. Burgess and O. P. Watts.

"Electrolyte Density in Storage Cells," by L. Lyndon.

"Errors in Pyrometry," by E. S. Shepherd.

"Laboratory Resistance Furnaces," by G. R. White.

"Electrodeposition of Bronze," by B. E. Curry.

"Electrolysis of Lead Acetate Solutions," by R. C. Snowdon.

J. W. Richards, M. DeK. Thompson, Jr., and C. L. Collins, 2d, are also to read papers, the subjects of which are to be announced later.

Operating Trains by Telephone

THE usual objection urged against sending orders by telephone has been the difficulty of having the orders recorded and placed on record. This difficulty has been overcome by the Minneapolis & Rainy River Railroad who, for over a year, have employed the telephone method in the operation of their trains and have found it to work successfully.

The method used is as follows:— Two men, usually the conductor and brakeman, enter a telephone booth to receive the orders for their train. In each telephone booth, of which the railway company now have fifteen in use, is a book containing blank forms consecutively numbered from 1 to 100. While one of the two men in the booth handles the receiver, the other writes in the book the order received. After written, it is repeated back to the sender and is then considered O. K., the men being held responsible for the execution of the order. Three copies of the order are made in the book, two of which are detached and taken by the men, while the third copy is left as a record and for the information, if necessary, of the next occupants of the booth.

The Edison Electric Illuminating Company, of Brooklyn, has arranged with A. F. Sheldon, of Chicago, for a course of instruction and lectures in "business-getting," to be given to about sixty employees in the canvassing department.

The Power Station

By FRED N. BUSHNELL, Chief Engineer, The Rhode Island Suburban Railway Company, Providence, R. I.

A Paper Read at the Recent Philadelphia Meeting of the American Railway Mechanical and Electrical Association

SINCE the advent of the direct-connected generator, the tendency in power-station design has been toward a more systematic and compact organization of the generating apparatus and the utmost simplicity of the entire plant consistent with the highest efficiency. The practice of different engineers has gradually worked toward a type of station which is now so generally adopted for street railway work where limitations are not placed upon the design by the size or shape of the available site, that it can fairly be said to represent standard practice in modern power station engineering. It embodies the following essential principles:—

1. Simplicity of design.
2. Subdivision of the plant into separate sections, so as to localize the effect of trouble to any part of the generating apparatus.
3. Provision for the symmetrical extension of the plant to provide for future power requirements.

THE GENERAL DESIGN

This station in its simplest form consists of a boiler room, engine and generator room, and switchboard gallery, arranged in parallel lines and separated from each other by substantial fireproof walls. In stations of very large size the boilers are frequently arranged in two tiers, or in groups, each group having its own chimney and flues and independent systems of feed and steam piping. This arrangement of the station is now generally referred to as the unit system, the distinguishing feature of which is that the boilers, engines and generating apparatus are arranged in separate units or groups, each one of which embodies all of the essential features of a complete generating plant, and the great advantage of which lies in the fact that trouble with any single piece of apparatus is localized, so that its effect is felt only in that unit of which it forms a part. Provision for carrying the load in the event of a breakdown of any important part of the apparatus is made by installing an additional or spare unit.

While the unit system is now almost universally employed in the larger power stations, it is usually somewhat modified for smaller plants where the liability to interruption of the service is not so great or the results so disastrous, the chief difference being in the arrangement of the steam and feed piping. The steam piping from the boilers is run to a longitudinal header, from which the connections to the engines are taken off at convenient points. This steam header is divided into sections by means of gate valves, which permit a section being cut out at the convenience of the operator for the purpose of making repairs. Usually two systems of feed piping are provided, one of which supplies hot water to the boilers through the heaters and economizers, while the second, or auxiliary system, supplies cold water, or water direct from the heaters, in case of trouble with the main system. This arrangement of piping provides sufficiently against interruption in small and medium-sized plants, and in a system carefully laid out with due consideration for the troubles which are likely to arise, it is hardly probable that the disarrangement of any one part will cause serious interruption of the service.

ALTERNATING OR DIRECT CURRENT

At the present time alternating-current generating stations and distributing systems are regarded as the most efficient to install in large cities where heavy traffic is distributed over a large area, requiring current to be delivered to the line at a number of points, and where the interest upon the investment in direct-current feeders and cost of their maintenance would amount to more than the same charges plus the conversion losses in an alternating-current system; and for long suburban or interurban railways where the power required at any one point is small as compared with the total power generated. The use of alternating-current apparatus has steadily increased since its introduction, until at the present time approximately 60 per cent. of the total power used by electric railways in the United States is generated by this type of apparatus.

In cities where the bulk of the business is within the economical radius of distribution for direct-current lines, and where direct-current generators form the larger part of the present equipment of the station, the common solution of the problem is to use this type of apparatus for city work, adding alternating-current apparatus to supply the more distant portions of the system, or roads operating through outlying districts.

There is undoubtedly a great advantage in having all the apparatus of a uniform type. This simplifies the wiring and switching part of the electrical equipment, and permits of a more efficient distribution of the load in the station. But there can be no conversion of energy without loss, and in cases where a considerable part of the system can be supplied with direct current without the use of rotary converters, the composite type of station will frequently be found to offer advantages in lower first cost and higher efficiency.

LOCATION OF THE STATION

The location of the power station, its general character, and the type of apparatus to be installed, depend to such an extent upon local conditions, that it is difficult to offer suggestions covering these points except in a general way.

If possible, the station should be located near an ample supply of water for condensing purposes, in order to secure the advantages from the use of the most efficient types of steam apparatus, and if possible, convenient also to a steam railroad or tide water, where the coal can be received and handled for the least expenditure of labour. Its location in reference to the distributing system will depend upon the extent and type of the system employed. If the direct-current system is used, it will be desirable to select a location as near as possible to its center of gravity, in order to reduce the investment in copper, but in the case of an alternating-current distributing system, this is of less importance, and greater consideration will be given to the cost of the available site, the nature of the soil, cost of foundations, etc.

The building should in all cases be

of fireproof construction and of neat and attractive design, appropriate to and suggestive of the purpose for which it is used. In determining upon the dimensions of the building, it is important that ample room be provided for all of the apparatus to be installed, so as to avoid unnecessary crowding. Passageways should be provided between each battery of boilers, and at the rear for the convenience of attendants in cleaning the tubes and connections and for making necessary repairs. Sufficient room should also be provided around each piece of apparatus in the engine room, so as to enable the attendants to inspect it regularly and keep it thoroughly clean, and to provide for the removal of any part in case of repairs.

In large cities, where land is extremely valuable, or the available area limited, the amount of power which can be generated per unit of ground area occupied is frequently the controlling factor in deciding upon the power station plans, and in such cases it is not always practicable to provide all of the space usually regarded as desirable for the convenience of attendants. This condition rarely exists, however, except in the larger cities, and in a great majority of cases no excuse can be offered for crowding the machinery to such an extent that it cannot be kept in proper condition and conveniently repaired by those responsible for the management of the plant.

Cleanliness is absolutely essential to the successful operation of an electric railway power station. It is necessary that the building itself be kept free from oil and dirt, and each piece of apparatus, thoroughly clean at all times, in order to maintain it in its highest state of efficiency. The designing engineer should contribute his share towards this result by providing ample light throughout the building—boiler room as well as engine or generator room. All the walls of the building should be painted in some light shade, preferably with some kind of enamel paint which can easily be washed down and kept clean. This will be found to reflect the light into dark corners of the building or spaces around the machinery, which might otherwise form receptacles for dirt and rubbish. It will add very much to the cleanliness and general appearance of the plant, and will contribute toward its successful running.

COST OF OPERATION

In designing a power station, the primary object in view is to deliver power at the bus-bars for the least expenditure of money, due importance, of course, being given to reliability of operation, which is the controlling principle in power station work. The fixed charges—interest, depreciation, insurance and taxes, should be as carefully considered as the cost of fuel, labour, supplies, repairs and other items which make up the operating expenses. Consideration should be given to each of these elements in proportion to its importance as a factor in the cost of power. In the great majority of cases fuel is the most important item of expense, frequently amounting to more than all other operating costs combined, and the perfection of these details of design and management which will effect the greatest economy in its use will usually make the best return for the time and labour expended.

Electrical apparatus has now been developed to such a state of perfection that in a well-designed and carefully managed power station over 90 per cent. of the power of the engines is converted into electrical energy and delivered to the transmission system, for the operation of cars. It appears, therefore, that no very great gain in coal economy is to be expected from the further improvement of electric generators or switching apparatus, and engineers are directing their efforts more than ever before to the steam portion of the power station, which offers a more promising field for a reduction in the cost of power.

The number and size of units to be installed is one of the most important problems bearing upon fuel economy which the engineer is called upon to solve. In order to obtain the maximum efficiency from the prime movers and their auxiliaries, it is necessary that they should be proportioned to the load they are intended to drive, so that if possible they may be operated at all times at or near their rated capacity.

In electric railway power stations it is not regarded as practicable to change the speed of the air or circulating pumps, or to alter the quantity of cooling water, to suit the varying loads upon the station, and these auxiliaries are usually operated at a point sufficient to take care of the maximum load. The power required to drive them is therefore practically constant, and their steam consumption per unit of output will vary indirectly as the load on the main engines. Under ordinary operating conditions, where the exhaust steam is used for heating the feed water, only about 12 per cent. of the heat in the total steam generated can be used for this purpose, and all steam used by the auxiliaries in excess of this must go to waste; and it follows that in addition to the losses due to the reduced efficiency of the prime movers at light loads, the percentage of loss in the auxiliaries will increase very rapidly as the load upon the main engine decreases, and the best economy of the entire plant will be obtained only when the engines are operated at or slightly above their rated capacity.

The writer has before him the operating statistics of two railway power stations, a comparison of which illustrates the importance of proper attention to this subject. For convenience they will be referred to as Station A and Station B. Both stations furnish power for suburban railways upon which sufficient cars are run to provide a fairly uniform load during the greater part of the day, although subject to more or less violent temporary fluctuations. The general designs of these stations and their equipments are such that the fuel used per KW.-hour should be practicably the same, provided the engines could be kept well loaded in both cases. In Station A there are three units, and the load conditions are such that one unit is operated during the night and early morning, when the travel is light; two are operated during the greater part of the day, and three at the peak of the load, which occurs shortly after 6 o'clock in the evening. By careful attention to the changes in the load, it is always possible to keep running engines fairly well loaded.

In the case of Station B there are two units. The load at night and early morning is very light, so that the engine used is only about half loaded for this period, whereas for the greater part of the day the load is a little more than one engine should be required to carry, and it is therefore necessary to run both engines. The result, of course, is that the average load on the station is only a little more than 50 per cent. of the rated capacity of the running engines, and they are, consequently, extremely wasteful of steam; and, too, the exhaust from the auxiliaries is probably quite a little in excess of that required to heat the feed water, which will also account, in a measure, for the low efficiency of the plant. Five pounds of coal per KW.-hour is the record of this plant, as compared with 3.8 pounds for Station A. The greater part of this discrepancy is undoubtedly due to the more efficient load conditions in the latter station. It is probable that had a storage battery been

added to the equipment of Station B, the load of the engines could have been regulated so as to have made a much better showing in coal consumption, but it is still problematical if there is any net gain from the use of storage batteries in railway work, and the writer is disposed to think that the use of three smaller engines in place of two large ones would have been the proper solution of the question. Undoubtedly a saving in coal of from 15 per cent. to 20 per cent. would have resulted from the use of engines better proportioned to the load.

THE NUMBER AND SIZE OF UNITS

In deciding upon the number and size of units, therefore, it is necessary that a careful study should be made of the load conditions throughout the entire day. In providing an increase of power for existing roads, data will be available from which station load curves under varying conditions of traffic can be constructed, and a fair average decided upon as the basis for determining the size of the units. In the case of a new railroad proposition, this information will be more difficult to obtain, and an approximate load curve will have to be constructed from a study of all of the conditions bearing upon the subject. This involves decisions upon such matters as the location of track, with special reference to grades and curves, the distribution of copper in the feeder system, the weight and equipment of cars, and trains schedules, all of which are important factors in determining upon the power required.

It is often necessary to estimate the size of a new power station before the final survey of the road is completed, or the details of the feeder system or train schedules definitely decided upon. In such cases the engineer will have to apply such data as he is able to obtain from other roads in which the conditions of track and the operating conditions are similar. But such data should always be used with the utmost caution, as vital differences in grades, in the feeder system, or in train schedules, must necessarily exist, which will render it extremely difficult to make comparisons sufficiently accurate for a final decision upon the size of the station.

Having ascertained the power required during the different hours of the day, the plant should be divided into as few units as will enable the engines and generators to be operated at or near their rated capacity, while at the same time a sufficient number should be installed so that in the event of trouble one can be shut down without causing interruption of service. A 3-unit station will permit of a fairly uniform distribution of the load in small plants, and in case of accident to one unit, the other two should be able by overloading, to supply sufficient power until repairs are completed. This number of units is therefore regarded as the minimum which should be installed in any power station.

RECIPROCATING ENGINES OR STEAM TURBINES

The type of apparatus to be used, whether alternating or direct current, will not materially affect the design of the station except in so far as the question of the use of reciprocating engines or steam turbines is involved. Up to this time the steam turbine, which is rapidly growing in favour for electric railway work, has been designed almost exclusively for use in connection with alternating-current generators, and the manufacturers of electrical apparatus have held out scant encouragement that its speed could ever be so modified as to make its use with direct-current generators, particularly the larger sizes, practicable. Reciprocating engines have, therefore, been regarded as the only type of steam motor available for this class of work. It is probable that this will be the case for some time to come, but it is interesting to note that considerable progress is being made in the development of direct-current turbo-generators. A number of machines of this type as large as 500-KW. capacity are in operation, and work is well advanced upon units as large as 2000 KW. There seems to be a good ground for the belief that this problem will be successfully solved, and that in the near future this type of apparatus will be available in sizes as large as are generally required for direct-current work.

Engineers and steam users generally have been prepared for some time to welcome any form of prime mover which could be shown to possess any considerable advantage over the reciprocating engine as the latter had come to be regarded as having largely fulfilled its possibilities, and no very great improvement in economy was to be looked for. The steam turbine seemed to offer the solution of the question, and while, at the time of its introduction into this country, its superior economy had not been demonstrated, its great simplicity as compared with reciprocating engines, lower first cost, and less floor space occupied, insured its prompt adoption by a large number of power users, and from the first its progress has been rapid. In a report of the committee for the investigation of the steam turbine made to the National Electric Light Association last June, it was stated that there were in operation at that time 224 turbines of an aggregate capacity of over 350,000 H. P., the greater number of which had been installed in the last two years. The writer is informed that the orders for turbines taken by the two largest manufacturers in this country aggregate (July 1, 1905,) over 800,000 H. P.

The remarkable progress made in the manufacture of these machines, and their general adoption by many of the most progressive railways in the country, prove them to be a most formidable competitor of the reciprocating engine, if, indeed, these do not indicate that they have already established their commercial superiority.

It is to be regretted that most of the data upon the efficiency of steam turbines has been derived from tests covering very short periods of time, usually only a few hours, and that so little data is available for their performance under actual service conditions. To the street railway manager or engineer, power station records for long periods, showing the coal consumed per KW.-hour, or, better still, the efficiency of the plant expressed in percentage of heat energy in the coal converted into electrical energy at the switchboard, are of much greater interest and value than the record of any number of short-time tests for steam consumption only, as they provide him with a much more practicable means of making comparisons with the performance of other stations with which he is familiar. The data which have been published illustrating the relative economy in steam consumption of turbines and reciprocating engines rarely ever show comparisons between units operating under identical conditions as to steam pressure, superheat, or vacuum and therefore do not fairly represent the relative performance of the two types, and, too, the steam consumption of the auxiliaries is also invariably omitted, so that it is impossible to form an intelligent opinion as to the additional cost of the higher vacuum required for the turbine.

Up to this time most of the turbines installed in electrc railway power stations are operated in connection with reciprocating engines, and owing to the difficulty of separating the operating charges, it has

been practically impossible to obtain reliable information as to their performance under commercial conditions.

One of the plants where turbines are exclusively used is the Quincy power station of the Old Colony Street Railway Company, and through the courtesy of P. F. Sullivan, president of this company, the writer is permitted to publish some information regarding the performance of this station. This information was kindly furnished by C. F. Bancroft, superintendent of motive power and machinery.

It should be stated at the outset that this station, which will eventually furnish power for that portion of the Old Colony Street Railway Company's system, extending from Quincy on the north to the city of Fall River on the south, is not yet in full operation. Its connection with the latter city, where a large part of the current is to be used, has not yet been made, so that at present it furnishes power for only about one-third of the number of cars which it will eventually drive. Only two of the five turbines in the station are required for this work. One of these machines is run for 17 hours per day, and two for 24 hours per day. When the station is in full operation there should be a more uniform load, and it is expected that the station efficiency will be considerably increased.

The station contains five 2000-KW., 4-stage turbines, running at 750 revolutions per minute, and connected to 13,000-volt, 25-cycle, alternating-current generators. The steam pressure is 200 pounds. There are 10 horizontal water-tube boilers of 750 H. P. each, equipped with internal superheaters, giving to the steam an average of 65 degrees superheat. Under-feed stokers are used. There are no economizers. One turbine is supplied with steam-driven auxiliaries; the other four have motor-driven auxiliaries. At present, while the two units are in operation, the feed water is heated to 200 degrees F. by the exhaust from the steam auxiliaries. The average daily output is 52,500 KW.-hours, giving a load factor of 54.7 per cent. for the two machines. Georges Creek Cumberland coal is used, having an average calorific value of 14,000 B. T. U. per pound. The average coal consumption for this station, operating under the conditions outlined above, is 2.94 pounds per KW.-hour, showing an efficiency of 8.36 per cent. This record covers a period of six months, ending June 30, 1905.

While this performance does not furnish conclusive evidence of the superiority of the turbine over reciprocating engines in electric railway work, it compares favourably with the results obtained in a large number of the better class of stations using the latter type of prime movers, and gives some force to the opinion that in actual practice there will be found to be very little difference in the coal consumption of steam turbine and reciprocating engine plants operating under similar conditions.

In order to develop the highest efficiency of the steam turbine, it is necessary to operate with a very high vacuum. It is claimed that each inch of vacuum above 26 inches will increase the economy from 3 per cent. to 4 per cent., and condensing apparatus is usually recommended which will produce a vacuum of about 28 inches of mercury, or 2 inches to 2½ inches higher than that regarded as the most efficient for reciprocating engines. The type of apparatus generally installed consists of a surface condenser with a centrifugal circulating pump, dry vacuum pump and hot-well pump. In practice no trouble has been experienced in obtaining the high vacuum desired with this type of apparatus, but whether the gain of 3 per cent. or 4 per cent. in coal is sufficient to warrant the additional first cost and cost of operating this rather complicated system, is a question which would seem to be open to discussion. In cases where the cost of feed water is a material factor in the cost of power, or where it contains a large percentage of calcium or magnesium carbonate, or other scale-forming materials, there will be great advantage in using a surface condenser on account of the pure distilled water returned to the boilers, but where these conditions do not exist, it will frequently be found practicable to use some simpler form of condensing apparatus, such for example as the injector or barometric type of jet condensers. These types of condensers offer very great advantages over the surface condenser in the matter of lower first cost, space occupied, greater simplicity and less cost of maintenance. Up to this time they have not been very generally used, but there seems to be no good reason why they should not work as satisfactorily in connection with steam turbines as with reciprocating engines, and when properly proportioned to the work and installed with tight piping throughout, it is believed that in many cases they will prove to be as satisfactory as the more complicated types. A considerable economy in the steam consumption of both reciprocating engines and steam turbines has been shown to result from the use of superheated steam. In plants equipped with either of these types of prime movers using dry saturated steam, the introduction of superheated steam can generally be depended upon to effect a saving in steam of about 1 per cent. for every 8 degrees or 10 degrees of superheat. Where the quality of the steam is not so good, and the conditions are such that the condensation in the pipes or cylinders of the engines is excessive, the saving may be much greater than this, sometimes amounting to 1 per cent. for every 4 degrees or 5 degrees of superheat.

With reciprocating engines, condensation in the cylinder resulting from the great difference in temperature between the incoming steam and the surfaces of the cylinder which have just been exposed to the temperature of the exhaust steam, has been recognized as one of the greatest sources of loss. Various means have been employed to reduce this loss, such, for example, as the use of steam jackets and reheaters, but these devices add materially to the complication of the engine, and under the most favourable conditions only affect a partial saving. For these reasons they have not been generally adopted in power station work. Superheated steam has been found to be a much simpler and more effective method of accomplishing this result.

Our knowledge of the subject of steam turbines is still so limited that it is impossible to state with any degree of positiveness just where the various losses occur, or to what causes we must attribute the gain in efficiency from the use of superheated steam. Undoubtedly a portion is due to thermodynamic reasons, and it has been suggested a large portion is also due to the diminution of fluid friction within the turbine. Owing to the very high steam velocities in this type of apparatus, the friction of the steam passing over the surfaces of the buckets must cause a considerable loss, and this probably is very much greater where the steam carries a large percentage of moisture than when it is dry or superheated. It is probable, therefore, that the larger part of the gain due to superheating can be attributed to this cause.

The prevention of the deposit of water on the inside of the turbine casing, also, must effect some saving, although this gain is probably small as compared with that resulting from

the diminution in the friction of the steam as it passes over the surfaces of the buckets.

USING SUPERHEATED STEAM

Whatever the causes may be, there can be no doubt that there is a very marked gain in efficiency in steam turbines from using superheated steam, amounting to about as much per degree of superheat as in the better class of reciprocating engines.

The following table, compiled by R. M. Neilson, shows the reduction in steam consumption in steam turbines and reciprocating engines due to superheating. These statistics were obtained from a number of tests made in this country and in Europe. The apparent discrepancy in these tests is explained by the statement that there was considerable difference in the quality of the steam in tne different cases, and the engines were of different types and of different sizes:

Steam Turbines.			Reciprocating Engines.		
Degrees Fahr. of Superheat.	Percentage Reduction of Steam Consumption.	Percentage Reduction per Degree Fahr.	Degrees Fahr. of Superheat.	Percentage Reduction of Steam Consumption.	Percentage Reduction per Degree Fahr.
13	6.1	0.47	31	7.86	0.25
50	8.0	0.16	40	8.65	0.22
60	5.4	0.09	50	12.00	0.24
66	12.1	0.18	100	20.55	0.20
70	7.5	0.11	100	13.00	0.09
84	7.7	0.09	216	36.4	0.17
100	14.0	0.14	225	33.7	0.15
140	12.6	0.09	225	33.1	0.15
150	19.0	0.13	440	30.9	0.07
200	23.0	0.115			
260	24.5	0.09			

Unfortunately, superheated steam is now known to be rather expensive to produce, particularly at the higher temperature, and consequently economy in steam consumption does not necessarily mean economy in consumption of coal. The chief advantage in its use is obviously in the saving which can be made at the coal pile, and unless this saving can be shown to be sufficient to pay for installing and operating the necessary superheating devices, it will be extremely difficult to convince careful street railway managers that it will be profitable to use it.

This is a subject upon which there is a vast amount of conflicting information. In a number of instances the use of superheaters has been discontinued either on account of mechanical difficulties or because there was not a sufficient saving in coal to pay for keeping them in service. In other cases no mechanical difficulties have been experienced, and the saving in coal has been all that could be reasonably expected.

It is noteworthy that manufacturers of reciprocating engines and steam turbines, as well as engineers, while still recognizing the value of superheated steam, are disposed to be much more conservative than formerly in recommending its use. At this time, the weight of opinion seems to be in favour of a moderate amount of superheat, say not exceeding 125 degrees. Within this limit there should be a sufficient saving at the coal pile to justify its use, while the temperature is not sufficiently high to cause serious mechanical difficulties with any of the various types of steam apparatus generally used.

THE BOILER PLANT

For many years after the inauguration of the electric railway industry, power station engineers seemed disposed to devote the greater part of their energies to perfecting the arrangement of engines, generators and switching apparatus, frequently neglecting the more important, though less showy, boilers and their accessories. In recent years they have come to realize that a larger percentage of saving can be made by a proper attention to the design and management of the boiler room than in any other department, as it is here that the greater number of preventable losses in a power station occur.

The designs of the standard types of steam boilers which are now generally used have been perfected to such a degree that efficiencies as high as 70 and 75, and even 80 per cent. have been attained under favourable conditions, and there are very few improvements which the power station engineer can suggest which will produce any considerable saving in fuel.

THE PROPER COMBUSTION OF COAL

The design of the furnace, as distinguished from the boiler, on the contrary, is one requiring careful thought and study, to make it conform to the conditions required for the perfect combustion of the specific kind of fuel which is to be used. Anthracite coal, owing to its small percentage of volatile matter, can be satisfactorily burned in almost any kind of a furnace, provided the grate area and the draft are sufficient to burn the quantity required to develop the desired capacity, but in the case of semi-bituminous and bituminous coals and lignites, containing a much larger percentage of volatile matter, the furnace should be so designed that this volatile matter, as well as the fixed carbons, will be completely burned in order to develop the full heating value of the fuel.

The following conditions are necessary to insure the complete combustion of the fuel:

1. A sufficient supply of air.
2. Thorough mixture with air and fuel.
3. A sufficiently high temperature of the air and the combustible gases to insure their ignition and perfect combustion before they come in contact with the cooling surfaces of the boiler.

The principal source of loss is due to imperfect combustion of the volatile gases, which are distilled very rapidly after fresh coal is placed upon the fire, and not being mixed with air at a temperature sufficient to cause ignition, pass off unconsumed; or the air supply and the temperature being sufficient, they are allowed to come in contact with the comparatively cool surfaces of the boiler, and their temperature reduced to below the ignition point before combustion is completed, so that they escape when only partially burned. The mixture, temperature and time are therefore important factors in the combustion of the volatile gases, and it follows that the combustion chamber should be of sufficient size to allow the gases to become thoroughly mixed, and that they should be raised to a sufficiently high temperature and be protected by fire-brick walls and arches from the cooler surfaces of the boiler shell or tubes until the combustible portion has been entirely consumed.

As to the proper place to admit the air for the combustion of the volatile gases, D. K. Clarke says:—

"It is a matter of perfect indifference as to effect in what part of the furnace or flue it is introduced, provided this all-important condition be attended to, namely, that the mechanical mixture of the air and gas be continuously perfected before the temperature of the carbon of the gas, then a state of flame, be reduced below that of ignition."

A number of furnaces have been devised in which the air has been admitted at the bridge wall or at the sides or front of the furnace above the grate, and there have been many ingenious plans for heating this air to the proper temperature before its admission to the combustion chamber. Some of these furnaces have been fairly successful as a means of reducing the smoke, but it is doubtful if the admission of air above the grate has ever materially increased the efficiency of the furnace. By far the most common practice is to admit all the air through the grate, that required for the combustion of the volatile gases being heated to the proper temperature by passing it

through the bed of incandescent fuel.

In many of the larger railway power stations the flue gases are regularly analyzed to ascertain the amount and distribution of the losses due to incomplete combustion and the amount of excess air admitted to the furnace, which information is necessary to enable those in charge to operate the boilers in the most efficient manner. The only way in which the waste which takes place in the furnace can be detected is by such an analysis, and its importance as a means of reducing boiler room losses is so great that it merits a much more general use.

In the combustion of coal the object in view is to produce the highest possible percentage of carbon dioxide per unit of fuel burned. The higher the percentage of carbon dioxide, the more perfect will be the combustion of the fuel and the higher the furnace temperature, as is shown from the fact that a pound of carbon burned to carbon dioxide will produce 14,600 B. T. U., while only 4450 B. T. U. will be produced when, on account of an insufficient supply of air, carbon monoxide is formed. The gas analysis will show the percentage of carbon dioxide, carbon monoxide and oxygen. This information will enable the chemist to determine the total heat in the escaping gases, the amount of unconsumed gas, and the losses due to an excess of air supply, and will also indicate the cause of these losses and suggest the proper remedy.

A low temperature of escaping gases is frequently regarded as an indication of efficient furnace conditions, but it is quite as likely to be caused by an excess of cold air, due to too strong a draft, uneven fires, or leakages through the boiler settings. The true condition of affairs can only be revealed by means of an analysis of the flue gases. Anything which will increase our knowledge of the conditions which take place within the boiler setting, and will permit a more intelligent use of fuel, should be encouraged, and for that reason the practice of analyzing the flue gases is recommended in all railway power stations where the cost of fuel is an important factor in the cost of power. It is always preferable to have this analysis made by an experienced chemist, but in small stations where the saving to be made is not sufficient to warrant the employment of such a man, it is said to be possible to obtain fairly satisfactory results from the use of one of a number of automatic or semi-automatic devices which are now manufactured for the purpose.

MECHANICAL STOKERS

Mechanical stokers are now almost universally employed in electric railway power stations, on account of the increased efficiency over hand-fired furnaces and the reduced cost of operation. In a properly constructed furnace of moderate size, equipped with flat grates, an intelligent and careful fireman will produce results equally as satisfactory as any which have been obtained with any of the various types of mechanical stokers; but the trouble is that such firemen are not plentiful, and it is extremely difficult to secure men who will produce uniformly good results for long periods of time. For this reason the average fuel economy in a railway power station will generally be found to be somewhat better where the firemen are assisted by some form of mechanical stoking device.

It should be borne in mind, also, that in order to ecomomize in space and the initial cost of the plant, the size of the boilers and the rate of combustion have steadily increased in the last few years until now a point is reached where it is doubtful if the larger sizes can be properly stoked by hand, even by the most competent firemen.

The use of mechanical stokers is necessary in connection with these large sizes of boilers, in order to drive them up to the capacity required in electric railway plants.

There can be no doubt that mechanical stokers accomplish a considerable saving in boiler-house labour. A reasonable day's work for a fireman is the shoveling of sufficient coal for about 500-H. P. of boilers, which in the railway power station will amount to from 6 to 8 tons every twelve hours. Where automatic stokers are used and the coal is delivered to the hoppers by gravity, one man should be able to take care of about 2000 H. P. of boilers, which is equivalent to a reduction in labour of 75 per cent. The cost of maintenance of automatic stokers is somewhat greater than that of flat grates, and additional labour is required for repairs as well as for tending the coal-handling machinery usually installed in connection with them, so that the net saving in labour will be somewhat less than that indicated above. There is a point, of course, at which this saving is not sufficient to pay for the additional fixed charges and repairs upon the mechanical stoking devices. In a plant of greater capacity than this, automatic stokers can generally be shown to return a sufficient net saving to warrant their use, while in smaller plants it will frequently be found to be profitable to use them on account of the cheaper grades of fuel which can be burned and the greater capacity which can be gotten out of the boilers.

PROPER ATTENTION TO DETAILS

Perhaps the most difficult problem to be solved in connection with the power station is to secure proper attention to details of operation by the subordinate employees. In the most carefully designed plant, equipped with the most efficient types of machinery, the results which the railway manager and designing engineer may reasonably expect in the way of economy will not be achieved unless the utmost care and vigilence are exercised by the operating forces. The successful operation of the station will depend largely upon the way in which the forces are organized, and discipline maintained. Just how the station organization should be made up is a question which can only be decided for each plant after a careful study of all the conditions; but it is safe to say that however the various departments may be organized, there should be one man in supreme authority, possessing considerable executive ability as well as a thorough practical knowledge of steam and electricity, whose decision should prevail in the event of disagreement among the heads of departments or at times of emergency. As he is the one who will be held responsible for the successful performance of the station, it is essential that whatever regulations there may be regarding the employment of his subordinates, he should have full authority to dismiss any who prove to be incapable or are not disposed to be attentive to their duties. It will be practically impossible to maintain proper discipline if among the employees there are those who feel a certain sense of security in their position through the influence of someone higher in authority than the man in charge of the station.

The work of the greater number of station employees is necessarily of a routine character. It is nevertheless important that the men should be thoroughly instructed in their duties and required to perform them with the utmost regularity. For example, an oiler employed upon an engine should receive instructions as to the minutest detail of the work that he is required to do. He should not only be required to see that his lubricators are full and working prop-

erly, and that every part is receiving a sufficient quantity of oil or grease, but he should feel of every bearing and should observe every part of the engine as he passes around it to assure himself that it is in proper operative condition. He should be required to perform these duties at regular intervals of every 20 or 30 minutes, and his attention should be called to the time for him to commence his rounds by a bell or whistle, or some other form of signal. If there is any part requiring attention, it should be immediately reported to the engineer in charge, who will thus be given an opportunity to apply the proper remedy before the trouble has developed to such an extent as to cause damage or interruption to the service. If the oiler attends to his duties properly, there will be no trouble from hot bearings, from keys, pins or bolts working loose, or from any change in the adjustment of any part which it is possible to discover when the engine is running.

The work of all other station employees should be systematized along the same lines. The watch engineers should report in writing to the engineer in charge, details of the apparatus which in their judgment require attention, and as soon as the machinery can be shut down, these parts should be carefully inspected, and if they show any signs of weakness or excessive wear, be immediately renewed or repaired. An examination of the enclosed parts of the engines and other working machinery should also be made at frequent intervals and before there are any outside evidences of trouble.

It is necessary that all subordinate employees should be under constant supervision to insure a proper attention to their duties, but this is especially true of the fireroom forces. Firemen are not generally disposed to take as much interest in their work as employees in other departments. They seem to be content to remain as firemen, and rarely endeavour, by excelling in their work, to advance their position. It is in this department that the greatest losses will occur through indifference on the part of the attendants, and it is therefore of the utmost importance that their work should be carefully done. The only way to accomplish this known to the writer is to place this department in the immediate charge of an intelligent and capable man, whose salary and the knowledge that the permanency of his position will depend upon the results produced, will be sufficient for him to keep constantly in touch with those immediately under him and insist upon their performing their duties properly.

KEEPING RECORDS

In most power stations records are kept of the coal and water consumption, the temperatures of the feedwater and the flue gases, and the station output, by which the performances of the station from month to month can be compared. These records furnish a check upon the condition of the station, the manner in which it is operated, and assure its being maintained in a high state of efficiency. The writer has found that in addition to these records, an occasional test of the entire plant under actual operating conditions for periods of say, 24 to 48 hours, is also of great value as a means of furnishing definite knowledge as to just what the station is capable of doing. Such tests also have a certain educational influence upon the employees, particularly the firemen, as they illustrate to them what can be done when all engaged on the work are exerting their best efforts to secure the most efficient results possible.

Auxiliary Poles for Large Direct-Current Generators

IN the design of large continuous-current dynamos for steam turbine speeds, says H. M. Hobart, in "The Electrical Review," of New York, it becomes necessary to introduce auxiliary windings in order to obtain satisfactory commutation. Without these provisions it becomes impossible, with fixed brush position for all loads and with carbon brushes, to avoid proportions leading to reactance voltages which would occasion sparking.

The most satisfactory solution from the commercial standpoint consists in the employment of auxiliary poles intermediate between the main poles. These auxiliary poles are furnished with windings carrying the main current, the windings being proportioned to provide a magnetomotive force at any and every load, not only sufficient to neutralize the armature magnetomotive force, but to provide a field of sufficient intensity and extent and of suitable direction to approximately neutralize the reactance voltage set up in the armature coils while short circuited under the brushes.

Auxiliary poles are more suitable the higher the speed, voltage and output. For a 750-KW., 250-volt design, running at 1500 revolutions per minute, they are necessary for good commutation. For 250-KW. machines for 250 volts and 1000 revolutions per minute, while designs with commutating poles are much cheaper and more satisfactory, good designs without them are still practicable.

Coming down to 100-KW. machines for 250 volts at 1000 revolutions per minute, the advantage which commutating-pole designs have over ordinary designs is but slight. At a somewhat lower output or speed there would, for 250-volt designs, be no choice. For still lower outputs and speeds, for 250 volts, the commutating-pole design becomes the more expensive. For a 100 revolutions per minute design, for 250 or even 500 volts, the preferable design would be without commutating poles, even in large capacities. At 200 revolutions per minute and 500 volts, commutating poles are desirable from, say, 400 KW. upward, and for 200 revolutions per minute and 250 volts from, say, 600 KW. upward.

These statements are only general and the preferable design depends very greatly upon the precise conditions for which the machine is to be used. In general, however, when heating and not commutation is the limiting consideration, the cheapest and best design will be without commutating poles, and vice versa when commutation is the limit.

The author concludes by giving the outlines for the electromagnetic design of a 750-KW., 250-volt machine running at 1500 revolutions per minute.

Electrical transmission of power is benefiting from the drought in California, says "The Scientific and Mining Press." The interruption to stamp-milling, by reason of the lack of water power, is prompting mine managers to install electric motors, to afford supplementary power sufficient to serve during seasons similar to that which has been experienced lately. This development will lead to the construction of more dams high in the Sierras and the organization of new power companies. At Grass Valley and Nevada City the use of electricity has been based on the utilization of the old ditches built originally for the hydraulic mines; but this is true also of the Mother Lode region. The loss of one branch of mining has been the gain of another.

A double-track tunnel equipped for electric traction is to be built by the New York Central Railroad under the Detroit River, to connect Detroit, Mich., with Windsor, Ont.

Artificial Illumination—XI

By DR. EDWIN JAMES HOUSTON

INTERIOR ILLUMINATION—Continued.

WE will now discuss the third type of artificial illumination, or that which requires the use of a light of marked brilliancy, with colour values closely approaching those of ordinary sunlight. In

FIG. 1.—AN ELECTROLIER FITTED WITH LAMPS MANUFACTURED BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG

all the cases which come under this head, i. e., ball-rooms, theatres, the lobbies, grand staircases, and dining-rooms of large hotels, bowling alleys, biliard rooms and barber shops, the entire space requires a brilliant and uniform illumination.

The highest type of illumination of this character is to be found in ball-rooms and on the stage of theatres when set for certain scenes. In the former case, the illumination should be of such a character as to ensure the maximum brilliancy, without, of course, unnecessarily dazzling the eyes of those in the room. The problem of properly lighting a ball-room is by no means one which is readily solved. Perhaps the most important condition is that the entire space of the room should possess a brilliant illumination of such colour values which at least will render it possible to properly display the various combinations of colours employed in the decorations of the room or in the dresses and costumes of the people present.

The sources of the light must be so placed as to ensure the entire absence of shadows, either on the ceiling, on the walls, or on the floor, especially the latter. Generally speaking, this latter requirement is not very difficult to fulfil, owing to the absence of any other objects for producing shadows than the people in the room.

Since the work done in a ball-room is not of such a character as to require the most distinct vision, it is not a matter of such great importance if the sources of light are so placed that some of the light can directly enter the eyes of the people in the room. On the contrary, since, generally speaking, the artificial luminous sources lend themselves readily to the artistic decoration of the room, the lamps are frequently purposely placed where they can be directly seen, in which case their light must, to a certain extent, directly enter the eyes of the observer. If, however, these lamps are properly shaded by transparent or translucent globes, their being placed where they can be easily seen is not objectionable in a ball-room.

Either arc or incandescent lamps are suitable for the illumination of a ball-room. If the arc lamps only are employed, they should be of the enclosed type, and preferably provided with translucent or strongly frosted globes. A combination of arc or incandescent lamps, however, produces a more pleasing effect than arc lamps alone, while, perhaps, the most pleasing effects possible are obtained by the suitable distribution of incandescent lamps of such high efficiency as to ensure a close approach in their colour values to those of daylight.

Perhaps the most artistic effects are obtained by placing the lamps on suitably distributed electroliers that are not brought too near the ceiling. To these may be added the artistic grouping of lamps supported by brackets on the walls of the room. The incandescent lamps are generally provided with frosted globes or with globes formed of some opaque or translucent material. Sometimes, however, very beautiful effects are obtained by the proper combination of clear and translucent globes.

The electroliers may be provided with ground glass prisms for the purpose of producing rainbow or prismatic tints, when observed from certain portions of the room. Where glass prisms are employed for this purpose, in order to ensure the best results, the colour values of the light employed in the room must at least approach sufficiently those of daylight to possess all the colours of the spectrum, although the percentage of these different colours may differ somewhat from that of ordinary daylight.

FIG. 2.—AN ELECTROLIER FITTED WITH LAMPS MANUFACTURED BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

The incandescent electric lamps employed should be provided with reflectors formed of practically transparent glass shades. Since light is

emitted both from the inner and outer surfaces of such shades, they serve admirably to add to the artistic decoration of the room.

It is because the well-known "Holophane" glass globes, manufactured by the Holophane Glass Company, of New York, lend themselves so admirably for the purpose of decoration, and also because of their ability to ensure a uniform distribution of the light, that they are especially suited for use in rooms like ball-rooms. Besides the Holophane globe, however, various devices can be very satisfactorily employed for entirely or partially surrounding the incandescent lamp so as to ensure a nearly uniform distribution of the light.

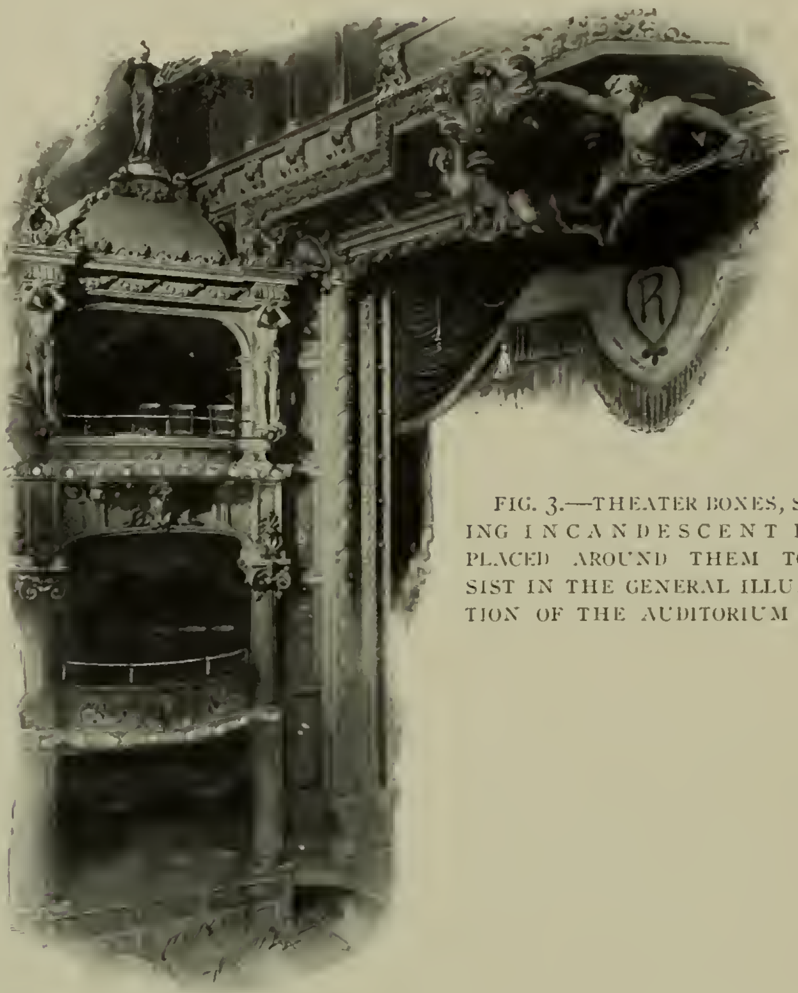


FIG. 3.—THEATER BOXES, SHOWING INCANDESCENT LAMPS PLACED AROUND THEM TO ASSIST IN THE GENERAL ILLUMINATION OF THE AUDITORIUM

Too great care, however, cannot be taken as to the character of the diffusing shades or globes employed in connection with the incandescent lamps intended for the illumination of a ball-room. Wherever, for any cause, the nature of these coverings is such as to result in rendering the illumination irregular or spotty, the artificial sources of light, instead of adding to the beauty of the room, greatly detract from it. The same is also true of electroliers provided with groups of lamps that are so placed as to produce marked shadows on the walls or ceilings.

FIG. 4.—A HOTEL LOBBY IN WHICH THE GENERAL ILLUMINATION IS OBTAINED BY INCANDESCENT LAMPS PLACED NEAR THE CEILING

The most important requirement for the illumination of a ball-room is the absence of shadows in any portion of the room, so that observers entering the room and expecting to see the most pronounced artistic effects, not only in the costumes worn, but also in the general decorations, will not observe disagreeable shadows, either in any part of the wall or floor space of the room, or especially in the globes or shades surrounding the sources of light. It is for this reason that the incandescent electric lamps should not be placed too near the ceiling of the room, unless the quantity of light employed results in the production of such a general illumination as to render the presence of shadows an impossibility.

For the same reason, the design of the electroliers should be such that no large mass of opaque material is placed directly above the lamps, or between the lamps and the walls, since this must necessarily throw shadows either on the ceiling or on the walls. Where, from the nature of the design, it is impossible to avoid this interposition, care should be taken in planning the distribution of the lamps that all such portions which would otherwise have shadows cast on them are illumined by other sources of light.

In the ornate form of electrolier shown in Fig. 1, unless a large amount of well-distributed light is employed in the room, the form would be objectionable on account of the comparatively few sources of light placed on the electrolier itself. This difficulty, however, would not exist if the general illumination of the room be good.

For the above reasons, bearing in mind the fact that the main requisite for the proper illumination of a ball-room is a marked brilliancy in the light provided, it should not be forgotten that the ordinary rules as regards the sufficiency of the illumination for other types of interior lighting cannot be employed in ball-room illumination. For such purposes, the truest economy is to be found in what might otherwise be regarded as a prodigal expenditure of light. A ball-room, generally speaking, can safely be fairly flooded with light,

provided it is artistically and scientifically done, i. e., thoroughly distributed throughout the entire space, so that no one portion of a room shall be much more brilliantly lighted than another.

Since in a ball-room the variously coloured costumes form, perhaps, the most important things to be illumined it necessarily follows that the daylight character of the illumination is a matter of the greatest importance. In order to properly reproduce the almost countless variety of different colours, hues, tints, and shades employed in the materials of the costumes, there should be present at least all the different colours that characterize the solar spectrum. While it is not absolutely necessary that these different colours of the artificial light shall exist in exactly the same percentage as they do in daylight, yet the closest approach to this will ensure the most satisfactory lighting.

When an artificial light is said to possess true daylight colour values, it should, strictly speaking, be understood to possess in itself not only all the different luminous frequencies of the wave lengths that are found in ordinary sunlight, but also in addition the same percentages of these different frequencies. It is evident, however, that although the artificial light produced by some illuminants very closely resembles ordinary daylight colour values, yet in perhaps the greatest number of cases artificial luminous sources differ from ordinary daylight in containing different proportions of the different colour values.

Since the most important requirement for the proper illumination of a ball-room is that the different coloured costumes be so illumined as to produce the best effects of colour contrasts, it would seem desirable if some standard of colour value for ball-room illumination could be agreed on. Thus, trials could be made before the purchase and manufacture of the goods, and especially after the goods are used in the costumes, of the exact effects that would be produced when exposed to the artificial light of the ball-room. This is by no means a matter of small importance when one considers the large sums of money that are spent in obtaining costumes, the principal effects of which are dependent on the production of proper colour contrasts.

Provided there is an abundance of approximately white light present in the general illumination of a ball-room, very beautiful effects can be obtained by the use in corners of the room not employed for dancing, or in the smaller rooms adjoining the ball-room, of variously coloured decorated lamps. A highly decorative fixture of this character, provided with differently coloured shades, is shown in Fig. 2.

For such purposes, the lamps employed are generally of the miniature type, provided with shades of red, green, white, blue, orange, and other colours, or suitable combinations of the different colours are sometimes used in the same shade. Decorations of this character are especially suitable for use in conservatories that communicate with the ball-room, or in portions of the grand staircase, or in halls adjoining such rooms.

There is, however, another possible type of illumination for ball-rooms that is capable of producing very satisfactory results, i. e., that in which the principal portion of the light necessary for the general lighting of the room is obtained by means of a great number of incandescent or arc lamps placed back of a skylight, the glass of which is either ground or of translucent finish. In this manner a powerful general illumination is obtained without the necessity for any of the light entering the eyes of those present. When this system is employed, however, it is generally advisable, for ornamental purposes, to use in connection with it an additional number of incandescent electric lamps placed either on electroliers, or on brackets, in the manner already described.

In the case of the ball-room, since the artificial light is employed in abundance, both the nature and the colour of the materials used for covering the walls and ceiling of the room are matters of comparatively small importance, because, however dark such coverings may be, there is presumably sufficient light employed for their proper illumination. As a rule, however, perhaps the most pleasing effects are produced where the colours employed contain a considerable quantity of whitish tints.

Coming now to the illumination of theatres, we must necessarily divide this character of illumination into two distinct parts:—The illumination of the stage proper, and the illumination of the auditorium. When the curtain is down, the illumination of the aduitorium should, in general, resemble that of a ball-room, at least so far as regards the lighting of the entire space. In order to bring out the many colours employed in the decoration of the modern theatre, as well as to properly illumine the costumes of the people present, this light should approach daylight in its colour values. Here, however, the light should be placed so as not to fall directly into the eyes of the audience, since this would prevent their obtaining the best results from the stage when the curtain rises.

FIG. 5.—THE DINING ROOM OF THE HOLLAND HOUSE, NEW YORK, LIGHTED BY WESTINGHOUSE LAMPS

FIG. 6.—ANOTHER HOTEL LOBBY. HERE CLUSTERS OF LAMPS ARE PLACED ON THE SIDE OF THE PILLARS

As soon as the curtain is raised, and the audience is supposed to have its eyes fixed on the stage, some suitable arrangement must be made so as to readily decrease the amount of light in the auditorium when it is increased on the stage.

The character of the light necessary for the proper illumination of the stage of course varies with the nature of the scene for which the stage has been set. For many cases the entire stage requires a brilliant illumination. For other scenes, how-

FIG. 7.—THE DINING ROOM OF THE HOTEL MANHATTAN, NEW YORK, IN WHICH WESTINGHOUSE INCANDESCENTS ARE USED FOR ILLUMINATION

ever, only an illumination of the ordinary brilliancy produces the best effects, while for still others, a light that is scarcely stronger than twilight is necessary. For these reasons there must be supplied a variety of devices whereby the amount of light can be readily varied from time to time to suit the different requirements of the play.

There is practically no light so suitable for the illumination of theatres as that of the incandescent electric lamp. These lamps are capable of being almost instantaneously lighted or extinguished by the action of a switch, or, what is still more important, can be varied in brilliancy to meet any requirement by the use of simple switching devices combined with rheostats, whereby the current strength passing through the lamp can be readily changed.

The footlights in theatres are placed so as to throw the light directly on the stage. This is done by means of opaque reflectors, or preferably diffusers, placed with their open face towards the stage and the opaque face so as to prevent the light from directly entering the eye of the audience.

Wonderful colour effects are produced on the stage, especially during the ballet, by means of lights so arranged that both their colour and intensity can be readily varied from time to time, as may be required by the scene for which the stage has been set. This is done by means of the suitable interposition of plates of coloured glass or gelatin between banks of incandescent lamps. In this manner, by employing white materials for the dresses of the dancers, the colour of the clothing can be instantly changed by changing the colour of the light employed in their illumination.

Where it is necessary to concentrate the light on a single part of the stage, any suitable form of reflecting apparatus is employed. In this case, as in the case already referred to, by placing coloured screens before the reflector, the colour of the light produced by this source can be readily varied from time to time.

The distribution of the lamps in the auditorium of a theatre, as in any other building, must be so arranged that different groups of lamps can be thrown in and out of circuit by means of suitably placed switches. Generally speaking, a large electrolier is placed near the ceiling of the auditorium, while horizontal rows or circles of lights are placed around the different portions of the building, such as the balcony and family circle. Fig. 3 illustrates a theatre provided with two such circles of light placed around the boxes.

The lobbies and grand staircases of large hotels require the same general type of illumination as is necessary for ball-rooms. Here a general illumination of high brilliancy is necessary, although the extent of this brilliancy is preferably not so great as in the case of ball-rooms. artistic decorative devices are especially employed. Incandescent electric lamps, which are almost entirely used for such purposes, are, in the case of lobbies and dining-rooms, placed in circles around the posts or pillars of the room, or on electroliers or brackets placed on the walls of the room.

Fig. 4 illustrates a hotel lobby in which the principal illumination is obtained from incandescent lamps placed, as shown, near the ceiling of the room. Two groups of lamps, however, are placed on the newel posts at the lower end of the grand staircase. In this case the illumination is good, although the dark colour of the decoration employed for the ceiling renders the proper illumination of this portion of the space somewhat unsatisfactory. As will be seen, the illumination of the floor space is excellent.

Fig. 5 shows the illumination of a hotel lobby. Here the light is principally obtained from clusters of incandescent lamps placed around the side of the pillars.

In order to obtain the brilliancy of illumination that is desirable in hotel lobbies, ball-rooms, and the like, a considerable advantage is gained by employing to some extent such ornamental material as white marble, alabaster, and plaster, since the brilliant illumination of such a coloured surface tends to add greatly to the artistic appearance of the room. This will be seen in the case of the illumination of the hotel lobby illustrated in Fig. 6, where the white marble pillars and facings around the clerk's desk, as well as the light decoration employed in portions of the ceiling, tend to produce very excellent contrasts of colour.

While for hotel dining-rooms the general illumination of the entire space is desirable, such rooms being employed, to a certain extent, for the display of dresses and costumes, as well as for eating, yet, of course, generally speaking, it is the surface of the dining table that especially requires a steady, uniform illumination. The daylight colour values are desirable in the light, both for the purpose of properly illuminating the costumes, as well as the different articles of food on the table.

It is especially to be observed in the illumination of dining-rooms that as the portion of the room which requires the maximum of illumination, —the surface of the table,—is provided with a background of so excellent a material as pure white linen, it is not difficult to insure the necessary illumination at this part. Where, as is frequently the case in hotels in the early morning breakfasts, the business man desires to read his newspaper while waiting to be served, the general illumination should be such as to throw sufficient light on the surface of the paper to render its reading an easy matter.

The distribution of the lamps employed in the illumination of the din-

ing-rooms of large hotels will, of course, vary with the architectural features of the room. If these rooms are entirely devoid of pillars and columns, the lamps can be employed in electroliers that are placed as near the surface of the table as will prevent the light from directly entering the eyes of the guests, and yet not so far from the ceiling of the room as will result in the production of marked shadows. Fig. 7 illustrates an illumination of this general character, in the case of the Hotel Manhattan, in New York City.

Where, however, as is generally tne case in large hotel dining-rooms, the ceiling is supported partly by pillars or columns, the lamps are placed in clusters around the sides of the pillars or columns, as shown in Fig. 5, illustrates the dining-room of the Holland House, New York City. The light obtained in this manner would, however, be insufficient for the general illumination of the room, so that these lights are supplemented by lights placed on electroliers.

The illumination of the drawing-rooms of hotels requires an amount of light that, while not as great as that required in the illumination of ball-rooms or lobbies, yet should be sufficient to illumine the entire space, and should be greater than that provided for ordinary interiors. Fig. 8 shows the illumination of the drawing-room of the Hotel Manhattan, New York City.

For the illumination of bowling alleys and billiard rooms of hotels, the requirements are practically the same as that for ball-rooms, lobbies, and the like. The entire space requires an especially uniform illumination on particular portions of the room, that is, on the surface of the alleys or on the surface of the tables. The distribution of the light must be such as to absolutely prevent the formation of any shadows, either on the balls or the pins, or on the surfaces of the tables or the alleys.

The most satisfactory manner of obtaining such light is by placing lamps under special reflecting shades, so placed as to throw the light on the surfaces before referred to, and to prevent any of it from directly entering the eyes of the players. In order to ensure uniformity in the illumination of the surface of the table, specially constructed shades should be used provided with a coating of material such as aluminium paint, which possesses the power of diffusing rather than reflecting light.

For the proper illumination of barber shops, a thorough lighting of the entire space of the room is advisable, though the intensity of the light need not, in such cases, be as great as in ball-rooms or lobbies. It is especially necessary, however, that a steady, uniform illumination of the face or the head of the person in the chair be obtained. The presence of shadows, since they tend to increase the chances of cutting, are, of course, highly objectionable. For the same reason, the light should be prevented from directly entering the eyes of the barber.

An exceedingly unsatisfactory method of illumination of barber shops is that which results by placing a number of incandescent electric lamps on the ceiling and walls of the room directly in front of plate glass mirrors. While such a manner of illumination produces the appearance of a great quantity of light, it is too apt to prevent the barber's distinct vision of his work which is necessary to avoid the accidental cutting of his customer.

The fourth type of interior illumination,—that which will enable workmen to distinctly see their work, —is, generally speaking, of a kind that is very different from any of the preceding. In this type, as a rule, the general illumination of the room is a matter of comparatively small importance, while the protection of the eyes of the workmen from the direct entrance of light from the luminous sources is a matter of the greatest importance. This simple rule cannot be repeated too often, on account of its great importance, namely, that in any case where work of a special character and requiring especial manual skill is to be performed, none of the light from the luminous sources should be permitted to enter the eyes of the workmen directly. The only light which enters his eyes should be that which is irregularly diffused from the surface of the work on which he is engaged.

There are so many different kinds of factories, mills, and workshops that the detailed requirements will necessarily vary as regards the amount of light, the necessity for its uniform distribution, and the approach towards true daylight colour values. Generally speaking, however, in all cases, this type of illumination requires a light of such a character as will ensure the work being distinctly seen by the workman. In some kinds of manufacture, however, the character of the work is such that, comparatively speaking, the workman is not required to pay very particular attention in order to ensure good work.

FIG. 8.—THE DRAWING ROOM OF THE HOTEL MANHATTAN, NEW YORK

The following general rules can be given for determining the different character of the illumination of the work that must be ensured in order to obtain the best results:—

Wherever the nature of the work is such as to require on the part of the workman a high degree of manual skill, its illumination should be of the best and highest character, both as regards sufficiency, uniformity and daylight colour values. So,

also, where, in the performance of the work, it is necessary to give considerable care to the proper running or operation of the machine, the machine itself, as well as the work,

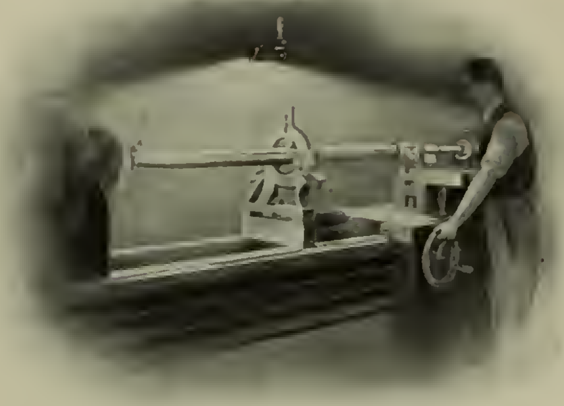


FIG. 9.—VIEW SHOWING THE DIFFUSION OF LIGHT FROM A METALLIC LAMP SHADE MANUFACTURED BY THE HENRY D'OLIER, JR., COMPANY, PHILADELPHIA

should be carefully illumined, so that all of its parts can be distinctly seen.

In accordance with this rule, it will be seen that some of the processes in factories require a very high type of illumination, while others require only illumination of an ordinary character. For example, for the proper preparation of the moulds that are employed in the casting of metals, a good uniform illumination is desirable; while the subsequent process of pouring the cast metal into the moulds does not require so high a degree of artificial lighting. Again, in the manufacture of paper, the sorting of the rags or the raw material, their cleansing, tearing, and the subsequent reduction to pulp, requires only an ordinary character of illumination. When we come to the operation of the Fourdrinier paper machine, however, an illumination of the highest type is necessary to enable the workman properly to prevent the loss of material by tearing, and the consequent loss of time from the frequent stoppages of the machinery.

Where the character of the machinery employed is such as may readily result in the loss of limb or life of a careless operator, the illumination of the machine should be such as to enable the moving parts of the machine to be distinctly seen, and thus reduce the number of accidents. Such work is to be found in the case of sawing and planing mills, or in rolling mills, where the heated metal is being drawn through the rolls, in the manufacture of stamped and spun metal objects, and the like.

In other types of manufactories, however, the general character of the work is such that the work done does not require any very high degree of illumination. This is true in the manufacture of soaps, chemicals generally, in the manufacture of leather, bricks, tiling, pottery, in the refining of sugar, in distilleries, flour mills, spice mills, and the preparation of paints and pigments. Here all the operations can be performed, and the finished product produced, with only an ordinary character of illumination.

In other types of work, however, such as the spinning and weaving of textile fabrics, in the composing and press rooms of printing houses, in the manufacture of watches, clocks, sity for the highest type of illumination of the work itself.

It is evident, from the above considerations, that the necessity for the presence of daylight colour values is of great importance in some cases, and of comparatively little importance in others. Where coloured fabrics are made, as in the weaving of carpets, dress goods, ribbons, and the like, the illumination of the objects by true daylight colour values is a matter of necessity, while in other cases it is a matter of comparatively small importance.

Where the work is of such a character as to necessitate a marked delicacy of handling, such as in the manufacture of clocks and watches,

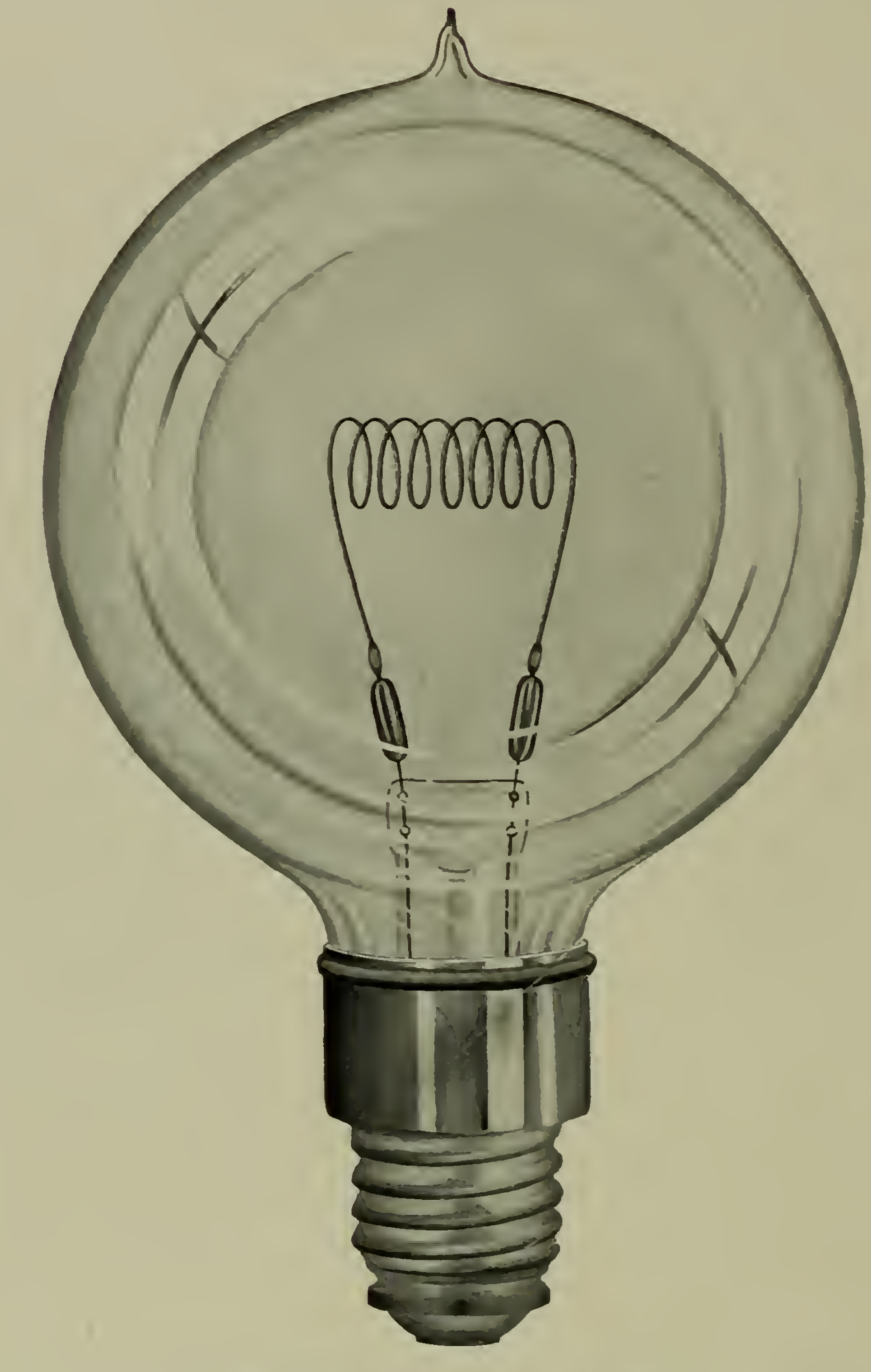


FIG. 10.—A 100-CANDLE-POWER INCANDESCENT LAMP MADE BY THE GENERAL ELECTRIC COMPANY FOR USE IN STEREOPTICONS

in the weaving of carpets, lace curtains, hosiery, cloths, dress goods, ribbons, and the like, where the use of the Jacquard loom is necessary, there is, generally speaking, a neces-

in so operating a printing press as to obtain the best impressions of matter containing a considerable number of illustrations, or for the proper printing of copper plates, or

steel engravings, a necessity exists for providing such an illumination as will ensure the most distinct vision.

It will be evident, therefore, from the above, that a very different character of illumination is required in the case of different kinds of factories, workshops, mills, and the like.

In the case of the illumination of mills where textile fabrics are woven, it is often a difficult problem to obtain such a general illumination as will ensure the absence of annoying shadows being cast by overhanging portions of the machinery. The extent of such difficulties will vary considerably with different types of machinery, and can best be met by a careful study of the particular requirements in each case. Generally speaking, however, by properly placing the sources of light, the shadows can in even the most difficult cases be avoided, at least to such an extent as to prevent any serious inconvenience to the workman.

In photographic galleries, where artificial illumination is employed for exposures and printing, there exists, of course, the necessity that the artificial light employed shall contain a large proportion of the so-called actinic rays, i. e., the rays capable of effecting chemical decomposition. These rays lie near the violet or the ultra-violet end of the spectrum. For this reason, the light of the incandescent lamp is not satisfactory, a lamp of the arc type being necessary.

For the proper illumination of machine shops, it is necessary that the work be given a uniform illumination, neither too powerful nor too feeble. The especial requirement here is that the light must not enter the eye of the workman directly, but after it has been irregularly reflected or diffused from the surface of the work.

In all cases where large machine tools are employed, the proper illumination of the work is necessary, not only in order to ensure the best results, but also in order to prevent that unnecessary wear and tear on the expensive tools employed, from lack of attention on the part of the workman, which would necessarily result from the improper or insufficient illumination of the tool.

It is a very questionable economy to fail to properly illumine both the tools and the work in a large machine shop, for, as a result of such economy there is a great probability that the wear and tear on an expensive tool will be greatly increased.

In the case of the machine tool shown in Fig. 9, a metallic shade, manufactured by the Henry D'Olier, Jr., Company, of Philadelphia, is so suspended over the tool as to throw its light both on the work and the tool, and yet prevent any of the light from directly entering the eyes of the workman. By the use of such a device, in place of the bare lamps suspended directly in front of the workman, there will be obtained the double advantage of ensuring a distinct vision of the work and at the same time throwing the light on the surface of the work.

There is one respect in which the illumination of machine shops and factories can be very greatly improved, both as regards the ordinary daylight illumination and the artificial illumination required at night. This is by giving more attention to the general character of the colour that is placed on the walls and ceilings of the rooms. In too many cases these are so completely covered with dust, oil and soot as to be prevented practically from diffusing any light which may reach them onto the tools or the work or on the floor of the room.

In many cases these walls have either never been whitened at all, or, if they have been originally painted, the colour has never been renewed, so that a very considerable loss occurs from the absorption of the light. A comparatively small expenditure for keeping the walls in a proper condition so as to permit them to diffuse any light they may receive, will very greatly improve the general illumination of the shop. The best material for use in so covering walls would consist of aluminium powder mixed into a paint-like form with any suitable vehicle which, on drying, would tend to bind the powder firmly to the walls.

The illumination of railroad stations does not greatly vary from that of other interior spaces. Where large waiting rooms are provided, the character of the illumination should be such as to permit the ready reading of newspapers and books while passengers are waiting for trains.

As regards the illumination of railroad train sheds, and the like, owing to the great height of the roofs of such sheds when at the ends of important railroad terminals, the illumination is best ensured by the use of arc lamps suspended so as to come comparatively near the platform. For such purposes a new type of arc lamp, known as the luminous arc, is most suitable.

This lamp possesses an arc of much greater length than that of the ordinary open arc. For this reason, since the carbons are further apart and a large proportion of the light comes directly from the arc itself, a far more uniform distribution of the light is ensured. The luminous arc is a variety of open-arc lamp and requires the use of a specially designed chimney to carry off the fumes produced by the peculiar

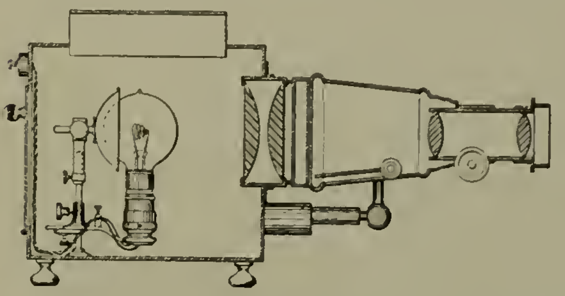


FIG. 11.—A STEREOPTICON FITTED WITH A GENERAL ELECTRIC LAMP OF THE TYPE SHOWN IN FIG. 10. HERE, HOWEVER, THE FILAMENT IS OF A CONICAL SHAPE

character of the electrodes employed. But this is not disagreeable in such a place as a train shed or a railroad terminal station. As in the case of machine shops, the surfaces of the walls of such train sheds are so darkened by the soot and smoke from the engines that little or no aid is obtained from the diffusion of the light which reaches them. Here, again, the expenditure of a comparatively small sum would ensure a marked improvement in the general illumination of the space. For

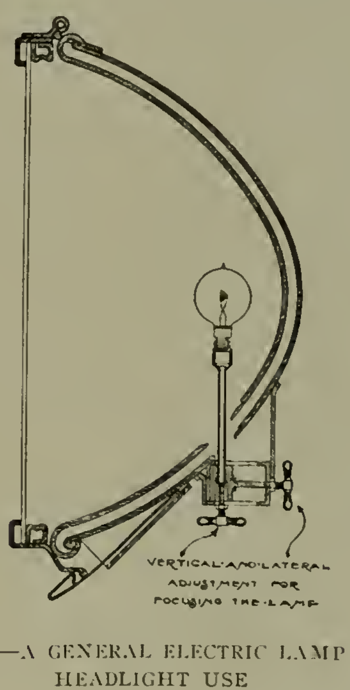


FIG. 12.—A GENERAL ELECTRIC LAMP FOR HEADLIGHT USE

the illumination of railroad sheds, the sources of light are generally suspended from the roof, so as to be sufficiently near to illumine the platforms provided for the convenience of passengers.

Since in subways and tunnels the illumination provided is, as a rule, for the use only of the engineers and train hands on the moving trains, the lamps are necessarily placed in such a position as to afford the proper illumination of the signals or other objects in the tunnel that may

be required for the use of the train crew.

In addition to the general types of illumination already referred to, there are certain special types of illumination to which attention should be briefly called before closing this series of articles on artificial illu-

FIG. 13.—AN EXPLORING LAMP MADE BY THE GENERAL ELECTRIC COMPANY FOR SURGICAL USE

mination. Only the most important of these will be referred to.

Now that the use of the incandescent electric lamp is so general, it is a matter of considerable importance to be able to employ such a lamp for use in the projecting or magic lantern. The requirement of apparatus of this character that the source of the artificial light must be concentrated as nearly as possible in the focus of the lens, renders neccessary a different form of filament.

Fig. 10 shows a form of the General Electric Company's 100 candlepower, 100 to 125-volt stereopticon lamp. This filament is given a cyl-

FIG. 14.—A GENERAL ELECTRIC LAMP FOR MICROSCOPIC WORK

indrical, spiral shape, experience showing that the best results are ensured when the axis of the spiral is at right angles to the axis of the magic lantern. In order to distribute the light uniformly over the screen, it is advisable to so focus the lens of the stereopticon as to throw the image of the lamp filament on the screen, and then shift the lamp up and down around its axis until a position is found which brings the greatest number of the coils of the filament into the focus on the screen.

Fig. 11 is a sectional view of a magic lantern provided with such an incandescent lamp. Here, as will be seen, the incandescent lamp is placed between a reflecting mirror and the condensing lenses of the lantern. By the use of this lamp, very satisfactory results have been obtained.

The laws of the different States regarding the necessity for providing all vehicles moving on public roads with suitable lamps, that must be lighted at night, have resulted in the use of various forms of lamps for carriages, automobiles and bicycles especially. These lamps consist of either oil, acetylene or incandescent electric lamps, especially the latter.

In a similar manner, incandescent electric lamps are now being extensively employed for the headlights of trolley cars. The arrangement of such a lamp near the focus of a parabolic reflector is represented in Fig. 12. In such cases the lamp is placed a little outside the focus of the parabola, so as to obtain, instead of the usual parallel beam of light, a slightly diverging beam, thus ensuring the lighting of a larger portion of the track.

In addition to the cases above referred to, reference may be had to the use of incandescent lamps for various purposes in dental surgery for the illumination of the interior organs of the human body, such, for example, as shown in Fig. 13. Here the exploring lamp is placed back of a convex lens and supported on the head of the operator in such a manner as to throw a conical pencil of light directly on the part under examination. Besides this, we may refer to the ingenious application of an incandescent lamp for the illumination of an object that is under microscopic examination, as shown in Fig. 14.

Reduction in Rates of Electric Lighting in Chicago

IN a report recently submitted by Bion J. Arnold, consulting engineer, and William Carroll, city electrician, to the Chicago City Council, is given what is considered a reasonable maximum rate for incandescent lighting. The report does not cover rates for special business, such as sign lighting, or arc lights for streets.

The Wright demand system of metering and charging is almost entirely used in the city, a wattmeter recording the kilowatt hours and a maximum meter showing the greatest demand at any one time. The rates are 20 cents per kilowatt-hour for an amount equal to a 30-hour use of the capacity indicated by the maximum demand meter, and 10 cents per kilowatt-hour for all current in excess of this amount. The maximum charge is subject to a discount of 20 per cent. for prompt payment of the bill, and the low rate is subject to varying discounts, according to the quantity used. No minimum is charged.

The report concludes that, if there is no desire on the part of the city to embarrass the companies (the Chicago Edison and the Commonwealth Electric) in their efforts to extend their lines and to render efficient and reliable service, then their offer to reduce their rates to 14 cents for the maximum rate, and 9 cents for the secondary rate, for two years from the present time, and to 12 and 8 cents for the next following three years, may be considered reasonable and fair.

A thorough investigation of the affairs of the companies might show that these companies could afford to reduce their rates to 10 cents and 5 cents (equivalent to a flat rate of $6\frac{2}{3}$ cents), but from all figures which have been submitted, this rate at the present time would be a hardship and would probably seriously embarrass the companies. It is reasonable to expect, however, that the companies can afford to and probably will eventually reach this latter rate.

Shopping by Telephone

WHAT is said to be the largest telephone system ever placed in a commercial establishment was recently installed in the store of Siegel, Cooper & Co., in New York. Knowing that a great majority of New Yorkers use the telephone, the management has had the store equipped with a system bringing a telephone within the reach of practically every clerk in the establishment. The telephones, which are at all counters and selling points, are connected with a large switchboard on the third floor.

The operators are trained carefully, and a person calling the store is connected immediately with the department or salesman desired. The operators transfer the telephone shopper from counter to counter, or department to department, as desired.

Welfare Work of the New York Telephone Company

By W. H. RADCLIFFE

WELFARE work or industrial betterment has within recent years become a prominent factor in the successful management of large manufacturing and operating companies. The work of the New York Telephone Company in this respect, doubtless largely aids it in transacting the vast amount of business involved in supplying satisfactory service to the quarter of a million telephone subscribers connected with its system.

Over 2500 operators are employed to attend to the wants of these subscribers, and while the company's methods of caring for the comfort of their operators have been liberal, they have not in general been carried beyond the point where the benefits resulting could not be almost immediately realized in increased efficiency of service.

New York Telephone welfare work has of necessity been controlled largely by circumstances peculiar to the telephone business. It may in consequence seem somewhat conservative in comparison with the methods for industrial betterment in use elsewhere, but the efficiency of the plan carried out by them and outlined here, recently won for them a silver medal and the highest praise and commendation from the officers of the International Exposition of Social Economy, at Liége, Belgium.

The character of the work will be discussed under three headings:—Hygienic and social betterments; financial betterments; and educational betterments.

Considering, first, the hygienic and social betterments, it may be stated in general that the operating rooms are large, airy, well lighted, and scrupulously clean. In all the large exchanges the female central office operators are provided with spacious locker rooms equipped with sanitary wire-netting lockers. Lunch rooms, where tea, coffee, and the like, are furnished by the company free of charge are also provided, and in addition there are perfectly appointed sitting rooms in which many of the current magazines and newspapers are kept on hand. Special attention is given the sick-bays and lavatories, all of which are under the charge of matrons.

Each operator's working day is divided into four approximately equal

THE OPERATING ROOM MAINTAINED BY THE NEW YORK TELEPHONE COMPANY FOR THE INSTRUCTION OF STUDENT OPERATORS

ONE OF THE NEW YORK TELEPHONE COMPANY'S CENTRAL OFFICES, SHOWING THE LARGE, WELL-LIGHTED QUARTERS PROVIDED FOR THE OPERATORS

parts by three intermissions of 15 minutes, 30 minutes, and 15 minutes, respectively, and during these intermissions use may be made of any of the rooms and conveniences provided. For such of the male central office employees so situated that they can avail themselves of the privilege, rooms are provided where they may spend their noon hours at luncheon, in smoking, or otherwise.

The financial betterments have been chiefly along the lines of providing faithful employees with steady work at as good pay as circumstances will permit, with liberal treatment in cases of sickness, accident, or death. A system of old age pensions is, however, under consideration and may be adopted later.

The educational betterments arranged for are intended to aid the operators, instrument setters, instrument inspectors, and splicers, in becoming proficient in the performance of their duties.

The educational work conducted for the operators begins when the applicants are engaged. Those who apply for positions as operators are first examined as to their general fitness for such work, and those who seem properly qualified are placed in the operators' school, maintained by the company, for a period of about one month. During this time they receive pay at the rate of $5 per week. The work in the school consists of lectures and practical experience, the former being delivered to graded classes and illustrated by complete diagrams showing the arrangement of the apparatus which the duties of an operator make it desirable for her to understand. Practical experience is gained by the handling of apparatus, a duplicate of that in use in the central office, and telephone calls originating and terminating within the limits of the school are made and completed in a manner exactly similar to that in actual practice.

An excellent idea of the practice obtained in the operators' school may be had from the accompanying illustration showing the operating room of the school. At the left is the switchboard, with the student operators seated in front of it. One division of instructors is shown standing immediately behind the students, exercising a constant supervision over all their methods. The calls handled by the students are made by another division of instructors who are sitting at the row of desks shown at the right. Although the conditions in the operators' school are made to approach the actual working conditions as closely as possible, it is not

A SITTING ROOM WHERE THE OPERATORS MAY REST AND READ THE CURRENT MAGAZINES AND NEWSPAPERS DURING THEIR LEISURE MOMENTS

LOCKER ROOMS SIMILAR TO THE ONE HERE SHOWN ARE PROVIDED FOR THE CENTRAL OFFICE OPERATORS

considered that the education of a student operator is completed with one month's practice. For a considerable period of time, varying with the individual, the training is therefore continued in the central office to which the student operators are assigned.

The educational work conducted for the instrument setters is under the immediate supervision of the chief foreman of instrument setters. He selects from the applicants those who seem most suitable for the work, and for a week those selected spend half of each day handling and using the simpler forms of apparatus with which instrument setters come in contact in the regular performance of their duties. After this practice the young men are regularly employed for about two months as instrument setters' helpers; they are advised to read and study as much as possible during this and succeeding periods, and a library is available for their use.

At the end of the two months, for a period of two weeks, half of each day is given to more advanced instruction. This general plan is continued for a year. The results aimed at are not merely to train these men as rapidly and thoroughly as possible in their duties as instrument setters, but also to select from among them the more promising individuals. Examinations are held, and the best of the men are transferred to the force, whose work it is to care for the central office switchboards and the lines leading from them. This work is considered of a higher grade, and the transfer is in the nature of a promotion.

The training of the instrument inspectors, although entirely distinct from that of the instrument setters, progresses along practically the same lines, with the ultimate promotion of the men to the central office force. In both cases the men receive pay, varying with their progress, while they are in process of training.

The men engaged in splicing underground cables are classified as "splicers," and "splicers' helpers." In general, additional splicers are obtained by promoting the more promising of the splicers' helpers. Candidates for positions as splicers' helpers are first sent to the splicers' school maintained by the company, where they are given typewritten information concerning the work which will be required of them, and the rules governing this work. They are then required to pass an examination upon the subject matter thus covered. In addition to this, they are shown how to perform the various operations which will make up their duties, under conditions which approximate those in the manholes. During this instruction the men receive pay.

After they have been at work for a while as splicers' helpers and before they are ready to be promoted to positions as splicers, they are again brought into the school for further instruction on necessary points. By the time they are qualified for promotion to splicer's rank, they have acquired by observation a reasonably thorough understanding of what will be required of them. This knowledge, however, is supplemented in the school by giving them an opportunity to acquire a degree of manual dexterity in splicing wires in working cables, and in making wiped joints of the lead sheathing which covers the cables. This work is done

LUNCH ROOM IN CONNECTION WITH THE CENTRAL OFFICE, WHERE THE OPERATORS ARE SUPPLIED WITH REFRESHMENTS BY THE COMPANY FREE OF CHARGE

THE LECTURE ROOM FOR THE INSTRUCTION OF STUDENTS IN THE OPERATORS' SCHOOL

under the supervision of one of the company's most competent practical men.

A form of welfare work in the New York Telephone Company, which combines both educational and social features, is the Telephone Society of New York, to membership in which all employees of the New York Telephone Company, the New York & New Jersey Telephone Company, the American Telephone & Telegraph Company, and the Western Electric Company, are eligible. Evening meetings are held monthly, except during the summer. These meetings are addressed by leading authorities on the various phases of telephone business, after which the meetings are open for informal discussion. The attendance is good, and much interest is manifested in the proceedings.

In the recent political campaign in England, some of the candidates availed themselves of the phonograph's services when they were unable to meet electors at various points. Their speeches were recorded in the instrument for repetition at meetings, and were varied by songs and instrumental music through the same medium.

Raleigh, N. C., is perhaps the only town in the United States having three separate telephone systems.

A Business "Booster"

As was noted in these pages last month, a part of the plan of the Co-operative Electrical Development Association consists in sending out literature containing suggestions to central station men for getting new business. This is now being done through the medium of several advertising agencies making a special study of electrical advertising service, which it will be

A list of applications of electricity for heat, light and power are given for the following classes of service: —Drug stores, saloons, residences, dry goods and millinery stores, apartment houses, laundries, blacksmiths' shops, and farming operations.

The pamphlet is written in a bright, conversational style, and makes interesting reading.

Increase of Stock by the Southwestern Telephone and Telegraph Company

The stockholders of the Southwestern Telephone & Telegraph Company, the Bell company operating in Texas and in Arkansas, held a special meeting in New York on March 20 to vote to increase the authorized capitalization from $10,000,000 to $20,000,000. At present there is $7,316,000 of stock outstanding. The annual meeting of the stockholders was held on the same day. In the past six months nearly all the Bell companies have voted to enlarge their capital stock, the total increase amounting to several hundred millions.

What is said to be the highest dam in the world has been built on the Salt River, Arizona, and will submerge and completely obliterate the town of Roosevelt.

The Co-operative Electrical Development Association

A Conference of the Electrical Trades at New York

FOR the purpose of considering the proposed organization of the Co-operative Electrical Development Association, mention of which has already been made in these pages, a conference of the various electrical interests was held on March 23 at the Hotel Imperial, in New York.

The business session in the afternoon was called to order by E. E. Jackson, Jr., who, after a few introductory remarks, gave way to J. Robert Crouse, of Cleveland, the moving spirit of the conference. Taking for his subject, "Profitable Co-operation," Mr. Crouse outlined the needs of organized effort on the part of the various electrical interests, and the plan for the formation of the association.

The ground on which the contention is based, he said, that co-operation is both feasible and fair for all the manufacturing interests, is the almost absolute dependence of the manufacturer who makes generating and distributing apparatus and supplies for his market upon the commercial activity of the manufacturer, who produces the final utilities through which the public is in the end electrically served. These are comparatively few in number, as will be observed. In the field of light, the incandescent, the glower, the tube, and the arc lamp; in the field of heat, miscellaneous appliances for domestic and industrial purposes; and in the field of power, the motor—endless in detailed application.

Likewise, in turn, there is the dependence of the manufacturer, jobber, and contractor, in varying degrees, upon the commercial activity of the central station and others in exploiting electric service to the public, and, ultimately, the dependence of us all upon this great, preoccupied, incredulous and indifferent public, with a purchasing power of twelve billion dollars, distributed among its eighty-five thousand individual units. The popularizing of electric service to this final market is certainly a common object, on the basis of which co-operation is correctely founded.

This great common market, the public, is obviously twofold:—First, the central station, whose entire business and interest is furnishing electric service at a profit, and within the range of whose service is comprised a population of 33,411,090 (see table on page 289), or 43.96 per cent. of the total population of the census of 1900. Second, the isolated purchaser to whom electric service, individually generated, is either partially essential or auxiliary,—always a means to some other purpose.

The commercial energy reaching this common market spends itself as follows, in whole or in part:—Manufacturer, jobber, dealer, contractor, salesman, trade paper, advertising. It will be observed that it is competitive in the highest degree and under constant spur to commercial activity.

The central station, on the other hand, is conceded by economists to be in its very nature properly monopolistic and subject therefore to no competition for like service. In consequence, laying aside any other adverse conditions, it lacks the keen and constant commercial stimulus.

It likewise lacks by reason of isolation either the ready opportunity or a very great incentive toward active aggressive co-operation. This, too, in spite of the fact that it is a natural situation where extensive co-operation as they are non-competitive among themselves reasonably promises the greatest results from such work.

The opportunity and the incentive are, therefore, offered to the manufacturers and others for initiating co-operative work with and for central stations and of cultivating the entire possible market broadly in addition.

Following Mr. Crouse's remarks, a number of other features of the movement were discussed, as follows:—"Possibilities of Newspaper Commercial Publicity," Ivy L. Lee; "Possibilities of Magazine and Periodical Advertising," E. E. Calkins; "Possibilities of Co-operative Work," Paul Spencer; "The Co-operative Movement from the Central Station Standpoint," W. H. Blood, Jr., president of the National Electric Light Association; "The Co-operative Movement from the Jobber's Standpoint," F. Bissell, of the F. Bissell Co., of Toledo, Ohio; "The Co-operative Movement from the Contractor's Standpoint," J. H. Strong,

W. M. MAC FARLAND

F. S. TERRY

Members of the Committee to Consider Plans for Organizing the Co-operative Electrical Development Association.

president of the National Electrical Contractors' Association; "The Co-operative Movement from the Trade Paper's Standpoint," J. M. Wakeman, of "The Electrical World"; "The Co-operative Movement from the Manufacturer's Standpoint," A. W. Burchard, assistant to the president, the General Electric Company.

It was then moved by Anson W. Burchard, and seconded by W. H. Blood, Jr., that "It is the sense of this meeting that the Co-operative Commercial Campaign for the purpose of increasing the use of electric current by the public for light, heat and power, as both an end and a means to the increased demand for electrical apparatus and supplies as presented and discussed, gives good promise of highly profitable returns to all concerned, and that the general plans for its prosecution through the Co-operative Electrical Development Association can be undertaken along equitable and practical lines."

It was also moved by Mr. Burchard, and seconded by W. M. MacFarland, acting vice-president of the Westinghouse Electric & Manufacturing Company, that a committee of eleven or more representatives of electrical interests be appointed by the chair for the purpose of considering the plans submitted for the organization of the Co-operative Electrical Development Association, and to complete and agree on a practicable form of organization with a view to putting the same into operation.

Resolved further, that this committee be authorized to confer on the subject with co-operating committees already appointed, or other representatives which may be appointed from other well-defined lines of the trade, so that adequate provision may be made in the plans of organization for immediate moral co-operation, as well as possibly financial co-operation at a later date.

Resolved further, that the plans of organization when completed by this committee be submitted to the representatives of the interests present, so that the entire proposition may be passed upon by their respective bodies or companies.

A—The number of cities and towns.
B—Population of cities and towns where electric service is available.
C—Number of light, heat and power plants.
D—Population, census of 1900.
E—Per cent. of total population where electric service is available.

States	A	B	C	D	E
Alabama	54	246,769	45	1,828,697	13.49
Arizona	16	41,946	14	122,931	34.12
Arkansas	62	173,654	63	1,311,564	13.24
California	186	968,456	175	1,485,053	65.21
Colorado	69	309,447	79	539,700	57.34
Connecticut	84	667,568	50	908,355	73.49
Delaware	11	97,292	9	184,735	52.67
District of Columbia	1	278,718	1	278,718	100.00
Florida	37	132,329	36	528,542	25.04
Georgia	81	406,352	78	2,216,331	18.33
Idaho	37	42,203	34	161,722	26.10
Illinois	394	2,968,077	397	4,821,550	61.56
Indiana	177	999,724	190	2,516,462	39.73
Indian Territory	27	42,756	27	391,960	10.91
Iowa	201	749,486	202	2,231,853	33.58
Kansas	83	404,252	87	1,470,495	27.49
Kentucky	76	497,307	83	2,147,174	23.16
Louisiana	37	410,557	38	1,381,625	29.71
Maine	87	329,050	75	694,466	47.38
Maryland	32	607,787	36	1,190,050	51.07
Massachusetts	167	2,410,769	126	2,805,346	85.93
Michigan	249	1,167,339	240	2,420,982	48.22
Minnesota	159	745,890	171	1,751,394	42.59
Mississippi	68	175,674	66	1,551,270	11.32
Missouri	145	703,767	154	3,106,665	22.65
Montana	24	97,937	29	243,329	40.24
Nebraska	73	288,716	74	1,068,539	27.02
Nevada	10	17,372	7	42,335	41.03
New Hampshire	68	270,992	55	411,588	65.84
New Jersey	154	1,432,524	97	1,883,669	76.05
New Mexico	13	34,251	13	195,310	17.54
New York	336	5,550,859	295	7,268,012	76.37
North Carolina	62	231,930	59	1,893,810	12.25
North Dakota	25	49,086	26	319,146	15.38
Ohio	268	2,199,008	274	4,157,545	52.89
Oklahoma	22	74,655	21	398,245	18.75
Oregon	56	168,995	45	413,536	40.86
Pennsylvania	396	3,705,916	317	6,302,115	58.80
Rhode Island	20	331,663	13	428,556	77.39
South Carolina	48	203,700	46	1,340,316	15.19
South Dakota	35	64,857	35	401,570	16.15
Tennessee	73	385,504	67	2,020,616	19.07
Texas	151	662,330	162	3,048,710	21.72
Utah	23	102,524	20	276,749	37.04
Vermont	61	151,536	48	343,641	44.10
Virginia	55	380,714	53	1,854,184	20.53
Washington	61	269,216	58	518,103	51.96
West Virginia	53	171,598	52	958,800	17.90
Wisconsin	181	947,742	178	2,069,042	45.80
Wyoming	18	40,296	18	92,531	43.55
Totals	4,828	33,411,090	4,538	75,997,687	43.96

A. D. PAGE

WM. H. BLOOD, JR.

JAMES R. STRONG

Members of the Committee to Consider Plans for Organizing the Co-operative Electrical Development Association.

When, in the opinion of this committee, a sufficient number of the interests have agreed to co-operate in the work, it shall be authorized to perfect the organization and to supervise its initiatory work.

The chairman of the meeting appointed the following committee, as covered by the foregoing resolutions:—

W. M. MacFarland, acting vice-president of the Westinghouse Electric & Manufacturing Company, Pittsburg, chairman; Walter Cary, the Sawyer-Man Electric Company, New York; A. D. Page, the General Electric Company, Harrison, N. J.; F. S. Terry, the National Electric Lamp Company, Cleveland, Ohio; W. H. Swope, the Western Electric Company, Chicago; W. C. Bryant, the Bryant Electric Company; F. J. Newbury, the A. Roebling's Sons Company; A. T. Clark, the American Circular Loom Company; W. H. Blood, Jr., president National Electric Light Association; F. Bissell, the F. Bissell Company, Toledo, Ohio, representing the electrical jobbers; James R. Strong, the Tucker Electrical Construction Company, representing the electrical contractors.

It is probable that other members will be added to this committee from other interests which it was expected would be present and whose representatives were unavoidably absent.

The business session was followed in the evening by a banquet, at which the subject was again discussed. W. M. MacFarland acted as toastmaster and the dinner was a most enjoyable one.

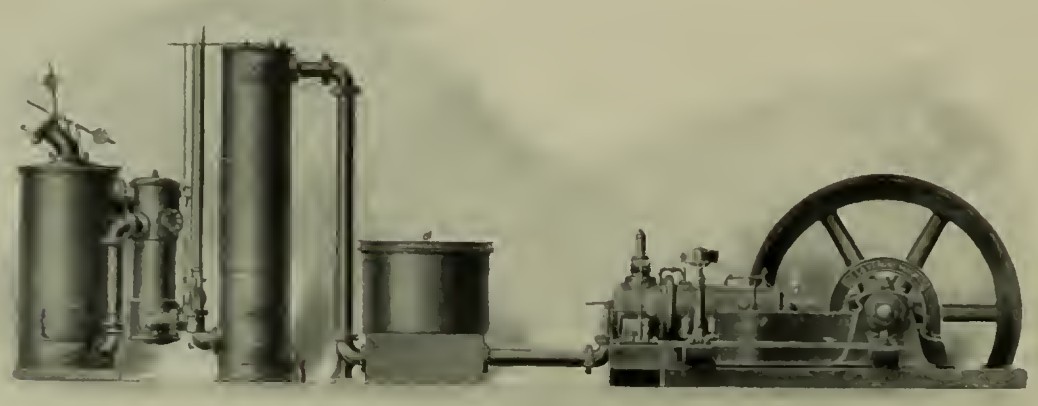
A neat little souvenir was an enameled pin in the shape of a magnet—the emblem of the association—bearing the initials C. O. D. A. and the slogan, "All together, all the time, for everything electrical."

The Koerting Suction Gas Producer

By Dr. OSKAR NAGEL

As suction gas producer plants are being more and more introduced into Germany, and as they are more and more replacing steam power in Europe, a description of the system which is mostly used over there will be of interest here. The system mainly used in Germany is the Koerting type of producer, and in the last four years over 4000 such plants have been installed.

A 75-H. P. plant, consuming less than 1 pound of coal per brake-horse-power, is running very successfully in the shops of the De La Vergne Machine Company, of New York, the American rights for the Koerting producers being held by them. This plant is shown in the annexed illustration. It consists of a producer, an evaporator, a scrubber, a sawdust purifier and a hand blower.



A KOERTING SUCTION GAS PRODUCER SUPPLYING A GAS ENGINE. THE AMERICAN RIGHTS FOR THIS PRODUCER ARE HELD BY THE DE LA VERGNE MACHINE COMPANY, OF NEW YORK

The producer consists of an upright cylinder made of wrought iron and lined with firebricks. Coal is charged through a double hopper, and poke holes are provided on the top of the producer. In order to allow easy access to any part of the producer, the clinker doors are made of large size.

In the evaporator, which is built along the lines of a tubular boiler, the water is heated by the gas going from the producer to the scrubber. Air is drawn over the surface of the nearly boiling water in the evaporator, and from here, saturated with steam, is led under the grate and through the fuel, converting the coal into producer gas.

From the producer the gas then passes to the scrubber. This is a simple wrought iron shell filled with coarse pieces of coke which are continuously sprinkled with water, thus washing all the dust and tar out of the gas. Three cleaning doors are provided for the scrubber.

Before going to the engine, the gas is filtered over sawdust in the sawdust purifier. The latter contains two wooden trays for holding the shavings and the sawdust. For plants of 75-H. P. and above, the sawdust purifier is an absolute necessity, as otherwise the gas will not reach the engine in a sufficiently clean state.

When starting operation in a producer plant, a wood fire is first started in the grate and blown up by means of a hand or power blower, the products of combustion being allowed to leave through the stack. When the wood is burning well, a few pailfuls of coal are put into the producer, and gradually more coal is added until the gas can be lighted at the test cock. The producer is then filled up with coal nearly to the top, the flue valve closed and the blower worked until a good flame is obtained at the test cock near the engine, after which the engine can be started.

Care has to be taken that water runs continuously into the evaporator and scrubber. After shutting down the engine, the air inlet to the evaporator is closed, one lower producer door is opened and the flue valve opened. This will allow a small draft to go through the producer to keep the coal burning over night. In the morning, the fire is cleaned from clinkers, the producer charged with coal up to the regular height and the blower started until

COMPARATIVE COST OF INSTALLING AND RUNNING A 75-H. P. PLANT

Kind of Power	Suction Gas	Steam	Ill. Gas	Gasoline
Cost of complete plant	$5,625.00	$4,500.00	$2,800.00	$2,600.00
Fifteen per cent. interest and depreciation	843.70	675.00	420.00	390.00
Cost of fuel per year of 3000 hours	562.50	1,350.00	4,050.00	4,500.00
Oil, packing, etc	150.00	150.00	100.00	100.00
Attendance	100.00	900.00	50.00	50.00
Total cost per year	1,656.20	3,075.00	4,630.00	8,550.00
Cost per H. P.-hour	0.73	1.37	2.05	3.80
Additional yearly expenses as compared to suction gas	......	1,418.80	2,973.00	6,993.80

a good flame is obtained at the test cock.

About once a month the fire has to be taken out of the producer and the walls of the latter cleaned of the adhering clinkers. The coke in the scrubber has to be renewed once a year and the sawdust in the purifier has to be replaced every two or three months.

The following data show the comparative cost of suction gas power, steam, gasoline, and illuminating gas power:—

1. Suction gas. 1 B. H. P.-hour is developed from 1 pound of anthracite pea, and costs $0.0025, with anthracite at $5 per ton.

2. Steam. 1 B. H. P.-hour in a plant of this size is developed from 4 pounds of coal. Taking the latter at $3 per ton, 1 B. H. P.-hour will cost $0.006 for fuel.

3. Illuminating gas. 1 B. H. P.-hour requires at least 16 cubic feet, which costs $0.018, figuring gas $1 per 1000 cubic feet.

4. Gasoline. Figuring the cost at 16 cents per gallon, 1 B. H. P.-hour will cost 2 cents.

The table on page 290 will give an idea of the comparative cost of installing and running a 75-H. P. plant with suction gas, steam, illuminating gas, and gasoline.

In practice the saving of gas as compared to steam will be very much greater, as in most localities the difference between anthracite and steam coal is not so large as given above.

Extensions to the West Allis Works for the Allis-Chalmers Company

THE new extensions to the West Allis (Milwaukee) works of the Allis-Chalmers Company will, when completed, add 861,000 square feet to the plant's present floor area of 652,000 square feet and make the entire plant capable of affording employment to 11,000 persons. The extended works, together with the capacities of the other works of the company in Milwaukee, Chicago, Cincinnati, and Scranton, will be capable of affording employment to a total of approximately 18,000 persons.

The extensions built are as follows:—Three machine shops, Nos. 1, 2 and 3, running east and west, parallel to the existing units, Nos. 1 and 2 being 575 feet long and 145 feet wide, and No. 3 168 feet wide; an erecting shop, 1136 feet by 113 feet, running north and south as an extension of the existing erecting shop and adjoining the six machine-shop units opening out into it; the extension of the existing foundry, north and south, which has a total length of 994 feet over all and a width of 222 feet, and the extension of the pattern and pattern storage building, which also has a length of 994 feet over all and a width of 119 feet.

The work of constructing these extensions involves an expenditure of over $3,000,000. Two buildings, the extensions to the erecting shop and the pattern shop, have been practically completed, while substantial progress has been made on the remaining buildings.

The West Allis site, situated in the town of West Allis, on the outskirts of Milwaukee, has a frontage of 1575 feet and runs back 2696 feet, or more than a half-mile, giving nearly 4,250,000 square feet of ground space, or about 100 acres, adjoining the tracks of the Chicago, Milwaukee & St. Paul Railroad.

The general plan of the West Allis works provides for two sets of building units, one composed of those in which the work is common to every class of product, like the pattern shops, erecting shops and foundry; the other group comprising the machine-shop units where the work is specialized for various machine operations. The two groups of buildings lie at right angles to each other; those of general utility lengthwise of the plat, north and south. The machine shops, six units in all, run crosswise of the plat, adjoining the erecting shop at the east end. Facing the ends of the machine-shop units Nos. 1 to 6, stands the foundry with its extensions, extending north and south. The pattern storage and shops stand farthest westward in the group and parallel to the foundry, with a span of 98 feet between them.

The system used for storing patterns and which renders each readily available for use when required, is greatly simplified by the use of electric telphers, running through the various sections, and by push cars and elevators. The telphers are supported on overhead I-beams and have a capacity of three tons each.

The yards between the various units are as completely equipped with cranes as the interior of the buildings, the storage space thus made available proving very serviceable.

Largest Power Station in Japan

THAT Japan is the centre of electrical development in the East is evidenced by the installation of the largest electrical generating station in the Empire for the Tokio Electric Light Company. This company already operates a steam-driven plant in the city of Tokio, and the new plant will meet the increasing demand for power. The new plant, contracts for which have been recently closed, is located on the Tamagawa River about twenty-five miles from Tokio, with which it will be connected by high-tension transmission lines, operating at a higher voltage than has been attempted heretofore in Japan.

At the station, the main generating apparatus will consist of five 3900-kilowatt, Siemens-Halske machines, direct connected to Escher Wyss water-wheels. The generators will deliver 50-cycle current at 6600 volts. All high-tension switches are of the General Electric oil type, motor-operated and electrically controlled from a separate five-panel bench board. This system of remote control is also carried out for the rheostats and circuit breakers, which are also operated from the bench board. This switchboard is similar to one used in the New York Interborough station.

At the generating end of the line, nine 2000-kilowatt General Electric transformers raise the voltage to 35,000 for transmission when connected in delta, or 57,000 when Y-connected. For the present the current will be transmitted at about 40,000 volts, but eventually 60,000-volt transmission is planned.

The receiving station will be located just outside the city, and will contain the main step-down transformers. The initial installation for the sub-station will consist of nine 1600-kilowatt units adapted to lower the voltage from either 33,000 or 57,000 to 11,000 volts. The arrangement is thus suitable for the transmission voltage at present planned, and also for future needs when the transmission voltage is increased to 60,000. The sub-station equipments will also be furnished by the General Electric Company.

From this station on the outskirts of the city, all wires will be laid underground to various small distributing stations located about the city, transmission being at 11,000 volts. As in the case of all electrical installations in Japan, the work is subject to a rigid government inspection, both before and after construction. Governmental approval having been obtained on the plans, and the station built, another careful inspection must be passed before the plant can be operated commercially. This rule covers all work of this character, whether it is fostered by private companies or the Japanese Government.

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Leading Articles

The Persistence of Constant-Current Dynamos

THOUGH more funeral sermons have been said over constant-current dynamos than over any other sort of electric apparatus, they are still with us. A quarter of a century ago, when the Brush and the Thomson-Houston arc dynamos were rapidly driving gas lamps to the back streets, and were the mainstay of the electric lighting industry, the doctors easily showed that such machines were poor, misshapen things, serving a merely temporary purpose.

Constant pressure rather than constant current was proved to be the natural output of any well-proportioned dynamo, and the degree of perfection with which arc machines operated was a measure of the badness of their design. Nobody cared to dispute so evident a proposition, but electric stations continued to use the arc dynamo because nothing else could be got to do the work.

Both arc and incandescent lamps were supplied on the constant-current circuits. Some of the incandescent lamps were connected in series with the arcs and carried the entire line current, as they do in a few misguided lighting systems to this day.

Many more of the incandescent lamps were operated in multiple, from those mysterious devices known as distributor boxes. When alternators came, the distributor boxes went, as they should have gone before, and it was said that the arc dynamos would soon follow. This was not hard to prove, because it seemed so easy to operate each arc street lamp with its own transformer, that nobody doubted it could be done. While the new plans were being perfected, however, the lighting stations wisely kept their arc dynamos going, and many are doing it yet.

Distribution of power in small units began early on the constant-current circuits, and, by 1887, there were 62 series motors connected to arc lines in Massachusetts, 31 of which were in Boston. This development reached its height about 1891, when there were 173 motors on arc circuits in Massachusetts, 83 of these being in Boston. Power distribution by this method lingered until 1902, when just one arc motor, located in Springfield, remained on the public lighting circuits of the State. So ended a method of motor operation that, in equity and good conscience, ought never to have begun.

The weak points of power distribution on arc circuits were the bad effect of motor operation on the lamps, the comparatively small amount of power that could be developed without a dangerously high voltage at the motor, and the imperfection of the speed-regulating devices. With constant-current circuits carrying 50 or 100 amperes, and devoted exclusively to power distribution, quite different results might have been reached. The practical disappearance of arc motors only helped to make more certain the predestined fate of constant-current dynamos, and the end was thought to be at hand a few years later, when enclosed arc lamps and the regulators and transformers for so-called constant alternating current were introduced.

After much discussion, however, it was well established that even in enclosed arc lamps direct current developed fully 25 per cent. more light, watt for watt, than did the alternating. On this showing, not a few managers of electric systems decided to keep their arc dynamos running a while longer, even though it was found desirable in many cases to drive these dynamos with motors instead of engines. Examples of this practice may be seen in Boston, where 3469 enclosed arc street lamps are operated by motor-driven, constant-current dynamos, and in Buffalo, where more than 2800 street lamps are so operated.

Constant-current electric traction got an early start at Cleveland, in 1885, with two bare iron conductors in a conduit between the rails. One Brush arc dynamo in the factory of that company furnished the current, and a similar dynamo on the motor car developed the power, but the system never got beyond the experimental stage. The fundamental objection to series electric traction is

that the supply of power for an entire system depends on the continuity of the circuit through each car, and it would, perhaps, be hard to find an engineer who does not think that the system is as dead as Julius Caesar.

In spite of the higher efficiency of direct-current enclosed arc lamps, constant-current dynamos have been falling behind in the construction of new plants during several years, because of the lower cost of alternating-current equipment. Some have recently thought that the time to write "Finis" over these dynamos was really at hand. But within the past few months particular attention has been called to developments that seem to imply the continued use of constant-current dynamos, on perhaps a larger scale than ever before.

One of these developments is the flaming or luminous arc, at least one prominent type of which requires direct current. These new arcs show such a large increase of efficiency over the pure carbon type that they seem certain to have a very wide use, in street lighting at least, and where constant direct current is necessary the dynamo of that type is its most probable source.

Of course, the constant direct current may be obtained from mercury-arc rectifiers connected to alternating circuits; but it remains to be shown that these rectifiers, with transformers, are more desirable for the purpose than are constant-current dynamos direct connected to alternating motors. The other promising field for an extended use of constant-current dynamos is electric transmission.

In Europe, for a number of years, M. Thury, an engineer with the courage of his convictions, has been advocating and installing constant-current dynamos and motors for long electric transmissions, in competion with the alternating systems. The practice is to construct each dynamo to operate with a constant current of 50, 100, or 150 amperes, and a voltage that varies from nothing up to a maximum of between 2000 and 4000, according to the load.

Enough of these dynamos are connected in series to develop any desired voltage at the generating station, and similar motors are joined in series with the line, at one or more sub-stations, to operate at its full voltage when working under their rated loads. In this way a number of transmission plants have been installed and operated at voltages up to as much as 30,000, and one such transmission is now under construction where the voltage is to be something like twice this figure.

So well considered is this system in Europe that it is proposed to employ it for the transmission from Victoria Falls to the Rand.

Tendencies in Motor Driving

THE economy of the motor drive when properly applied has now been demonstrated by several years of rapid progress. In this time almost every machine known to the industrial world has been added to the list of appliances which produce better results when operated by electricity than by any other form of energy.

In the rapid development which the application of the motor drive has passed through, a great deal has been learned about the influence of the specific type and arrangement of motor upon the work to be accomplished. The exigencies of the situation have often prevented that thorough study of each particular installation which is necessary to insure the application of the best kind of drive in a given problem.

Hasty decisions have, therefore, frequently resulted in the installation of an outfit not well adapted to the purposes in hand, and in some quarters the opinion has grown up that there is, after all, very little economy in the motor drive in comparison with the older methods. The mistakes, however, have also indicated to the engineer the practices to be avoided.

A large amount of data has been printed of the power consumption of various kinds of machinery, but in far too many instances there has occurred great discrepancy between the figures, for the reason that the essential particulars of operation were not stated. A notable exception to this dearth of detailed information is found in a paper read in January of this year upon the "Power Required by Machine Tools," by G. M. Campbell, before the Engineers' Society of Western Pennsylvania.

In this paper, a thoroughly scientific analysis of the power consumption of direct-connected tools is presented, with full particulars of the make and size of tool, speed, depth of cut, feed, character and weight of material treated. The point is emphasized that these particulars must be known before intelligent appreciation of the conditions of operation can be had, and there is little doubt that the selection of motors for industrial service would proceed on a much more rational basis if data of this character were more generally available.

At the present time, the alternating-current motor has mainly been applied to constant-speed work, outside the railway and elevator fields, but there is no doubt that in the near future variable-speed, direct-driven, alternating-current machine tools will be largely used. The advent of the single-phase motor has immensely quickened the interest of central stations and consumers in the possibilities of alternating-current machine-tool service, and the tendency of large industrial plants to migrate to or spring up in suburban districts will naturally stimulate a demand for alternating-current service from the central station to the consumer's motor.

In cases where the required speed control is not of wide range—and many installations are contented with a range of 2 to 1—the alternating-current motor is capable of admirable service, although at present the first cost of this type for variable-speed work is rather too high to enable it to compete with the direct-current machine, except in situations where distance of transmission is great enough to make a notable saving in copper. For constant-speed work, the induction motor occupies a field which can seldom be usurped by the direct-current machine.

Probably the most notable development in motor driving at this time is found in the compensated direct-current motor. The manufacturing companies have for some time realized the necessity of providing the consumer with a direct-current motor which should be capable of speed variations with economical hand control over a range as high as 6 to 1.

Control through armature resistance adjustment gives a high range of speed, but it is naturally very wasteful of power. Within two years, this method has fallen into utter disfavour, even on large street railway systems operating single-motor cars consuming from 1000 to 1200 watt-hours per car-mile, with power costing but 1 cent per kilowatt-hour delivered at the wheels.

The problem was solved through field control, and the appearance on the market of various successful designs embodying the supplementary pole idea, augurs well for the extension of variable-speed, direct-connected motor installations. A great advantage of this type of motor is found in the ease with which an installation can be extended; there is no balancing with motor-generators, and no complication of circuits as with the three and four-wire multiple-voltage systems.

The high-range types of variable-

speed motors are much larger and heavier than their predecessors, for a 25 or 30-H. P. frame may be necessary for a 6 to 1 speed range in a so-called 5-H. P. motor. Even these larger motors occupy only a small fraction of the space of the tools which they drive, so that the objection on the score of size is not a very serious one, except in the matter of increased cost.

Sometimes the owners of industrial plants have hesitated to install the motor drive, fearing that it would mean a general change in the establishment's policy. The representatives of the manufacturing companies may not always have convinced the owner that the saving in power will be sufficient to warrant the change, and it is frequently difficult to predict or guarantee a specific increase in the production rate, for the reason that the conditions in different plants vary so widely.

In such cases it must be borne in mind that the complete motor outfit need not be installed all at once; the heaviest machines can be attacked first, and then, when the results are seen, the smaller units can be equipped. Free movement of traveling cranes and a brilliant flood of natural light are now recognized as of increasing importance, so that in new work of this character in an old plant there is almost always a chance to effect a striking change for the better.

Probably there is no more difficult question in electrical practice at this time than to determine when the group drive is best and when the individual drive is most desirable. The tendency is certainly toward the latter, for with the group drive, even under the best conditions, one encounters many of the losses and troubles due to the old shafting and belt methods of power transmission. It is largely a question of being able to afford the direct drive, and with the recent improvements in motor-speed regulation, the outlook is very promising for a wider employment of direct-connected motors in all classes of service.

Wireless Telegraph Stock Jobbing

NEWS comes from a Western city that, after a practical exhibition of wireless telegraphy in a hall of the town, accompanied by voluble promises on the part of the exhibitors of trans-Atlantic telegraphy, numerous cotton brokers were induced to invest in the stock at par, namely, $100 per share. After the excitement had died down, the brokers in question took occasion to wire their stock brokers in New York concerning the value of the stock they had bought, and were somewhat chagrined to learn that the stock was freely offered at 29 on the open market.

In the meantime, the exhibitors had gathered up their apparatus and departed for pastures new, where, there is little doubt, they will gather in new victims. This is about on a par with the scheme which a firm of Philadelphia stock brokers are now working on gullible investors with relation to the same wireless stock. The scheme deserves to be as widely exposed as possible. The firm in question sends out broadcast by mail circulars containing extravagant accounts of the prospective earnings of wireless telegraphy.

It is intimated that $100 invested in this wireless stock now, will return 1000 per cent. profit in a few years. In the meantime, they offer the stock at $100 per share and guarantee 5 per cent. interest per annum on the stock for five years, together with any dividends in excess of 5 per cent. that the company may earn in that time.

Assuming that the stock brokers should pay the promised 5 per cent. for 5 years, it is obvious that they would still be getting $75 per share for a stock that, as already mentioned, is now selling on the open market at about $30 per share. It may be taken for granted that the stock has not cost the stock brokers anything like this price.

Schemes of this kind are of so deceptive a character that it is rather difficult to classify them with others of a bona fide nature. It is proper to say in this relation that the managers of the wireless telegraph company concerned disclaim any connection with the stock brokers who are working the foregoing scheme.

Electricity and Automobile Shows

THE recent automobile show in Boston illustrated to a large degree the flexibility of electricity as an exhibition auxiliary. There is no gainsaying the inference that without this cleanly agent, the full rounded success of the displays at Mechanics' and Symphony Halls would not have been attained. The vitiated atmosphere produced by thousands of gas jets would have been distinctly disagreeable and unpopular, and as a matter of fact, the superb finish and intricate mechanical design of the modern automobile could not have been shown at night to good advantage except with the aid of the electric light.

Aside from its uses in a decorative way—and the incandescent lamp in the form of coloured bulbs played a most artistic part in the ornamentation of the larger exhibits—electric lighting was admirably employed in miniature bulbs to illuminate working models of pumps, tachometers, engines, valves and transmission gear, all of which were necessarily driven by small motors operated from the power circuits of the different hall sections.

Large lamps were used to flood the under sides of the automobiles with light, so that every part of the mechanisms could be readily seen, and the effect of these lamps when used in conjunction with large plate mirrors lying upon the floor beneath the cars was excellent. Miniature lamps were also employed to light the interiors of limousine cars.

The small motor was simply indispensable, for it was entirely out of the question to introduce the gasoline fire risk into the two halls. Purchasers and other visitors were thus enabled to observe the detailed operation of the automobile mechanisms in a way which would have been impossible on the road or under their own power, although an out-of-door test exhibit played a vital part in the consummation of actual sales.

From the cyclometer and the pneumatic horn to the engine mechanism, the small motor met the exhibitors' requirements unobtrusively and efficiently, and the telephone and telegraph completed the electrical conquest of the auxiliary means of making the exhibition a success.

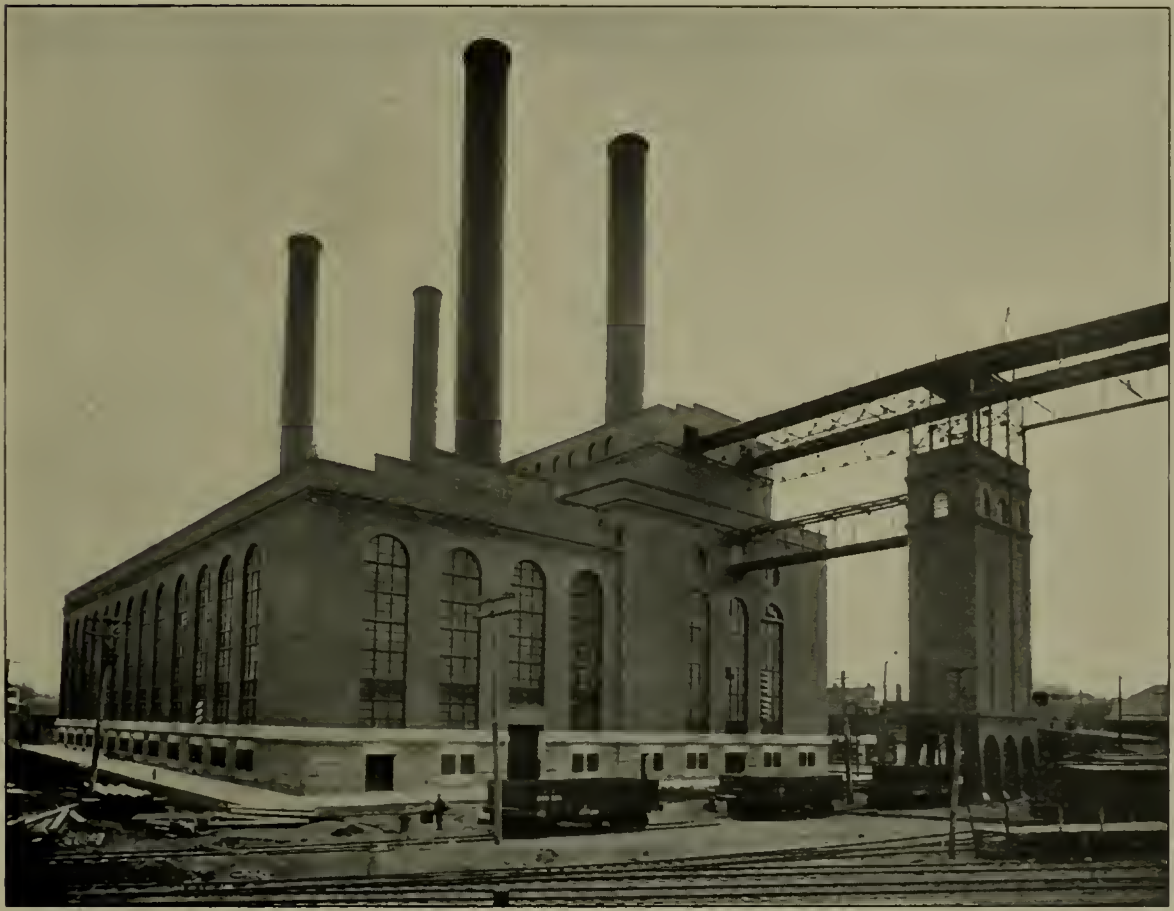
Announcement has been made by the College of Engineering, University of Wisconsin, of the complete list of non-resident lecturers who are to address the students in engineering during the coming year. The lecturers selected include some of the most prominent authorities on special phases of engineering in the country. The lectures are not confined strictly to engineering topics, but include the consideration of various industrial and commercial problems with which the engineer is brought in contact. Among the subjects pertaining to electrical engineering, "High Speed in Modern Engineering" will be discussed by B. A. Behrend, chief electrical engineer of the Allis-Chalmers Co.

The West Shore Railroad is to be operated on the third-rail system between Syracuse and Utica, N. Y.

The New York and Long Island Extension of the Pennsylvania Railroad

The Long Island City Power Station

In the series of articles of which the present one is the first, the Pennsylvania Railroad's extension to New York and Long Island will be described, with the present and future equipment for the generation of electric power and the operation of electric trains from New Jersey through the Hudson River tunnel to Manhattan Island, and thence under the East River to Long Island. In the present article the power station at Long Island City is dealt with. Although part of this great project—the Long Island Railroad electrification—has already been described in THE ELECTRICAL AGE, the matter here given is in greater detail.—The Editor.



THE LONG ISLAND CITY POWER STATION OF THE PENNSYLVANIA RAILROAD. THE ASH TOWER AND A PART OF THE CABLE RAILWAY STRUCTURE ARE ALSO SHOWN

THE Pennsylvania Railroad Company has had under consideration for a number of years plans for establishing a terminal for its lines on Manhattan Island. The earliest of these contemplated a bridge over the Hudson River, with elevated approaches and terminal in New York.

The demonstration that electric traction was practicable for heavy train units made possible, however, an entrance by means of tunnels, which would enable the building of a terminal that would embrace not only the Pennsylvania Railroad main line business, but also through connection with New England and the railroad system on Long Island. The announcement that the Pennsylvania Railroad Company proposed to enter New York City was made in May, 1902, and since that date the project in all its features has been actively under way.

POWER HOUSE LOCATION.

The enormous scale of development of the large terminal system, which is to be entirely operated by electric power, very early led to the decision that to secure reliability of service, as well as convenient power distribution, there should be two main generating stations, sites for which could be more readily obtained if they should be located, one in New Jersey and the other on Long Island. The latter station would also naturally be used as the main source of power for the Long Island Railroad lines as fast as equipped, and the electrification of the Atlantic Avenue improvement, which was impending when the general project took shape, required the early construction of the Long Island City power station.

On account of the very large amount of power that would eventually be needed by the new lines, which are to tunnel under the East River near the present terminus of the Long Island Railroad at Hunter's Point, and also by the Long Island Railroad suburban lines, which are now concentrated at this terminus, it was obviously desirable to locate the power station conveniently to the district that would eventually be the scene of such a concentration of electric railway activity.

The site in Long Island City, besides providing a condensing water supply, has an additional advantage of a location convenient to the Long Island Railroad freight yard, enabling both the cheap handling of coal and ashes by rail, as well as the minimum expense for delivering building materials and equipment during construction. It consists of an entire rectangular block with the short side toward the river, extending 200 feet north and south on Front Street and on West Avenue, and is 500 feet deep along Third and Fourth Streets.

FOUNDATIONS.

For the foundations, piles were driven at a compartively uniform spacing and overlaid by a monolithic concrete mass. This cap is 6½ feet thick, except under the stacks, where the thickness is 8½ feet, the piles being cut off 2 feet lower down. The stack anchor bolts pass through a grillage of T-rails embedded in the bottom of the concrete.

INTAKE FLUMES.

The flume for the condenser intake, and the overflow flume directly above it, traverse the building foundations completely from west to east, and are integral with it. Both

GENERAL VIEW OF THE POWER STATION AND THE COAL AND ASH-HANDLING STRUCTURES. COAL IS HOISTED AT THE COAL TOWER AND DUMPED INTO A CAR RUNNING ON THE CABLE RAILWAY. IT IS THEN CARRIED TO THE BUNKERS AT THE TOP OF THE POWER STATION

the intake and the overflow flumes are nominally 10 feet in diameter, this large sectional area being required to provide sufficient condensing water with a low velocity of flow when the power station is extended to its maximum future length of 500 feet and filled with generating machinery. The elevation of the intake flume is such that it is always submerged. At a point 50 feet from the bulkhead the tunnels separate, the overflow tunnel passing at an angle of approximately 15 degrees with the centre line of the intake. The intersection of the overflow with the bulkhead is oblique, with the object in view of producing a long, slow flow at the outlet.

The spillway of the flume is formed up into a dam, the object of the dam being two-fold:—First, to insure a water seal on the discharge pipes of the condenser circulating system; and second, to spread the warm water on the surface of the harbour to prevent its mixing with the condensing water entering through the intake.

COAL AND ASH HANDLING STRUCTURE.

The rather unusual height of the coal tower was due to the adoption of the level cable railroad to convey the coal from the hoist to a position where it could dump by gravity into the coal pocket, without any intermediate hoisting operations.

The completed structure may be said to consist of three parts, the coal hoisting tower, the bridge supporting the cable railroad, and the ash bin structure, which is so arranged that it forms a part of one of the piers of the cable railway bridge. This level bridge is 107 feet above the dock, and is at about two-thirds the entire height of the tower, the top of which is 170 feet above the dock.

The floor on which the hoisting apparatus is located is 25 feet above the dock, and the space around and over this floor is enclosed for a height of 14 feet, forming an engine room for the hoisting mechanism.

The upper third of the tower, extending above the level of the cable railway, carries the hoisting boom, the receiving hopper, coal crushing and weighing apparatus, and the cable railway machinery. The boom is 68 feet long over all, and projects $43\frac{1}{2}$ feet beyond the northerly face of the tower and over the slip at an elevation of 162 feet above the dock. It supports the trolley carriage from which the hoisting bucket is suspended.

For about 34 feet above the level of the cable railway the upper third of the tower is completely enclosed with corrugated copper sheathing, forming a house with two stories, the lower one of which contains the weighing mechanism, the engines driving the crushing machinery and the cable railway, while the upper story contains the crusher. The roof of the crusher room is formed by the receiving hopper, in the form of an inverted pyramid.

The ash bin is directly across Front Street from the boiler room, and ashes are delivered to it through a bridge by means of a telpherage system, which hoists and transports the ash cars from the boiler room basement up to the level of this bridge and thence over into the tower, where the contents are dumped into the bin.

Engineering necessity dictated the construction of the ash bin directly in front of the boiler house, so situated in the freight yard that ashes can be dropped from it by gravity. The bottom of the bin is 20 feet above a railroad track running

through the base of the tower, and the ashes are handled through dumping gates into gondola cars standing on this track.

The cable railway is in the form of a loop, and is operated by an endless cable. After the coal is hoisted, it is dumped into the pocket already mentioned, and then into a car on the cable railway. Three separate steam engines are used for the operations of hoisting, opening and closing the buckets, and for trolleying. The railway has a capacity of 150 tons per hour, when operating twenty-nine 2-ton cars at a speed of 180 feet a minute around a track loop about 2500 feet long. Ten cars are used at present.

POWER HOUSE.

The power house may be said to consist of three parts, namely, the boiler house, the coal bunkers, and the engine room. The boiler house consists of two floors and a basement, and is divided into a series of equal bays, each marked by a single arched window extending past all the floors. The coal bunkers are above the boiler house, longitudinally between the four stacks. A cross-section of the coal bunkers closely resembles the letter W, this form being the consequence of having a double line of boilers with an alley between them requiring a downflow of coal by gravity at points directly over the boiler fronts. The engine house includes also the electrical switching galleries and offices.

STATION CAPACITY.

At the time the design was undertaken, the extent of electrification in sight was such as to necessitate a station capacity of not less than 50,000 KW., and probably more. When the decision was made, the largest size of steam turbines and generators that had been standardized was of 5500 KW., and this size, therefore, became the unit basis of the power station design.

The rectangular shape of the lot, practically 200 by 500 feet, made it possible to plan a station that could readily be extended to occupy the entire block. The adopted design will permit the disposition of fourteen 5500-KW. generating units in the building covering the block, or about 105,000 electrical horse-power, if such an amount of power be eventually required.

For the initial load that was to be placed upon the power station during the earlier years of the Long Island Railroad electrification, it was decided that three 5500-KW. units would suffice. The building, as designed for this initial equipment, covers the full width of the block and half its length, and contains room for six 5500-KW. units and two 2500-KW units of the same type to be used for lighting the tunnels.

As now built, therefore, the station can hold more than double its present equipment, and when extended in size, will accommodate more than four and one-half times the original installation of electrical generating machinery.

The unit system of design was followed in laying out the equipment of the power station. The boiler plant of thirty-two boilers is divided into eight groups of four boilers each, four of these groups being on the first floor, and four directly over them on the second floor of the boiler house. The four boilers of each group stand opposite each other across an alley or firing space, and are separate as regards economizer, flue, and stack connections, but their steam connections are made so as to join them into groups for the purpose of unit sub-division.

ASH HANDLING SYSTEM.

Ashes are dumped through hoppers in the bottom of the stoker pits into small cars so constructed that the body is detachable from the truck. After receiving a load of ashes the car is run along a narrow gauge railway laid in the basement floor underneath the line of dumping hoppers to a turntable at the west end of the boiler house basement directly under the end of the ash bridge.

A trolley hoist is provided from a point over the ash bin through the bridge and over the turntable. From the trolley carriage are suspended, by means of wire cables, two sheaves with forged-steel hooks, which are inserted in the rings at each end of the car body as it stands on the turntable in the basement. The trolley hoist then raises the body to the proper height opposite the ash bridge, at which point by the action of an automatic switch the operation of the hoisting is stopped, the trolley motor is started, and then the car body is carried to a point over the ash bin, automatically dumped, reversed, returned again to the inner end of the trolley hoist and finally lowered to the turntable in the boiler room basement. The entire cycle of operations is effected by hand control of a single starting switch, the

THE ELECTRICAL OPERATING GALLERY, SHOWING THE MOTOR-DRIVEN EXCITER, INSTRUMENT BOARD, AND SWITCHBOARD

control of trolleying, dumping and lowering being entirely automatic, the attendant simply closing the pilot switch.

BOILERS.

The boiler plant consists of thirty-two Babcock & Wilcox water-tube boilers set in batteries of two boilers each, eight batteries on the first floor and eight on the second floor immediately over the former; these batteries are equally distributed on each side of the boiler plant, with a firing space between boiler fronts of about 18 feet in width. Each boiler is fitted with a Roney stoker.

Of the four stacks, only two are required for the operation of the present equipment. When the station is extended, two more will be added.

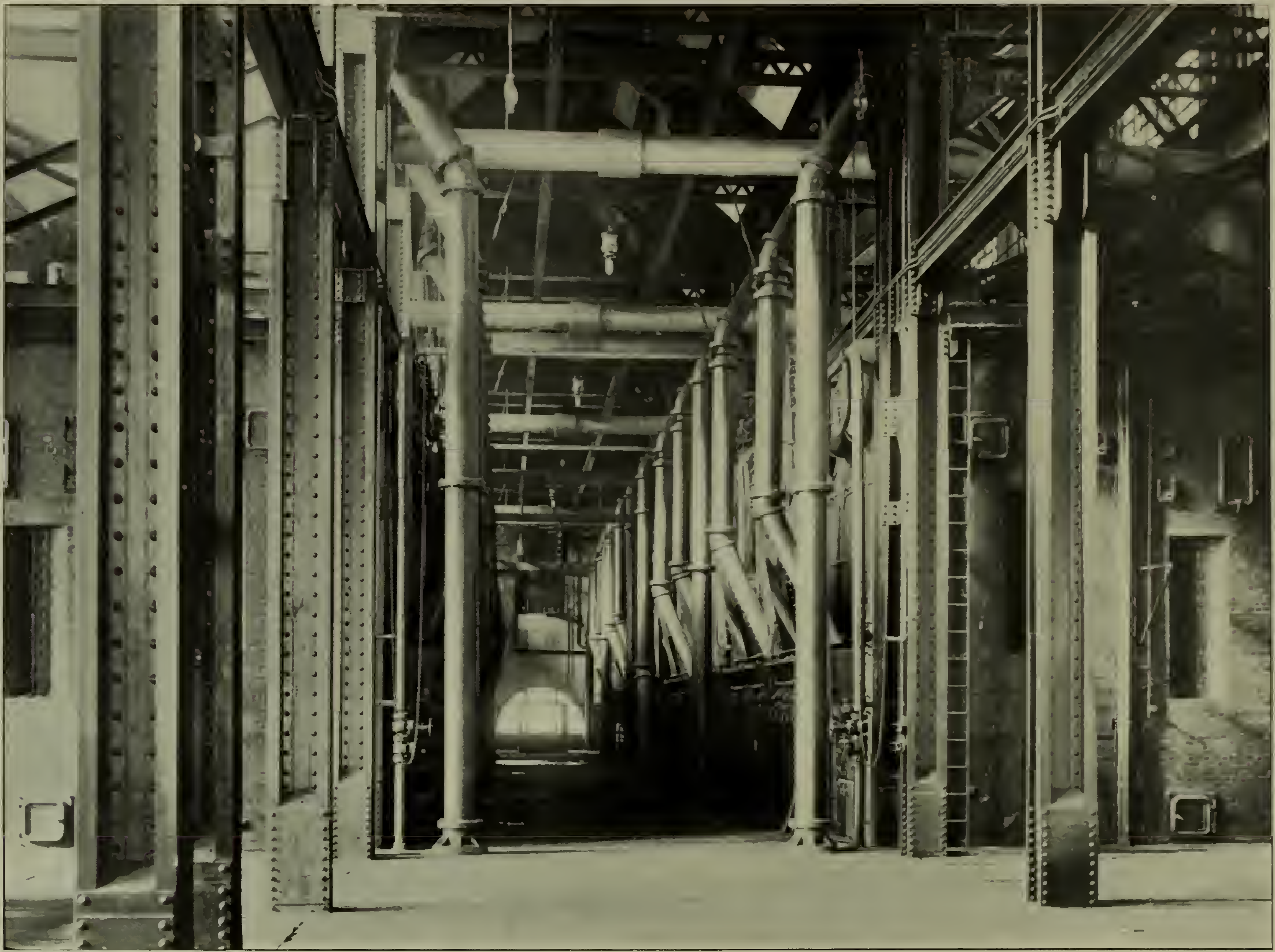
GENERATING UNITS.

For the initial equipment three main generating units have been installed, consisting of steam turbines direct connected to three-phase, 11,000-volt generators of the revolving-field type. The turbines are of the Westinghouse-Parsons single-flow type, rated to develop 5500 kilowatts at 175 pounds steam pressure, and 27½ inches vacuum, running at 75 revolutions per minute. An Alberger condenser of the counter-current type is provided for each turbine.

The generators are star-wound, and the field is separately excited at 220 volts from three separate sources, namely, two steam-driven exciters, one motor-driven exciter, and a storage battery. These are designed to give direct current at from 180 to 220 volts. The steam-driven engine units each consist of a Westinghouse-Parsons steam turbine directly coupled to a 200-KW. direct-current turbo-generator, designed to run at 1800 revolutions per minute.

The motor-driven exciter, also of 200-KW. capacity, is driven by a 290-H.-P., three-phase, 440-volt induction motor, both motor and generator being mounted on the same shaft, bearings, and bed-plate. This motor-driven exciter is located in the operating gallery. The three-phase motor derives its current from three 175-KW. oil-insulated, self-cooling transformers located in the basement of the electrical gallery.

The storage battery is intended mainly as an absolutely reliable source of supply for the exciter bus system and the other more important auxiliaries. It is installed in a specially arranged room in the engine room basement, and consists of 110 cells, each containing seven plates. The tanks are built large enough to ultimately contain eleven plates.



THE SECOND FLOOR OF THE BOILER ROOM, CONTAINING SIXTEEN BABCOCK & WILCOX WATER-TUBE BOILERS

SWITCHBOARD APPARATUS.

The generators are designed to run in parallel on either of two sets of main bus-bars, called the "working" and the "auxiliary" bus, only one set of which is generally in use.

The switches for the outgoing feeders are arranged in groups of six (three only of each group being installed at present), the feeders be-

ing tapped from an intermediate or "group" bus. In order to distribute current to the feeders, therefore, it is first necessary to connect a group bus to either the working or the auxiliary bus, and this is done by providing each group with two selector circuit breakers, one for each of the two sets of main bus-bars. Thus, any generator, or any group of feeders, can be connected at will to either set of main bus-bars.

The cables are run through the turbine foundations into the basement (where taps are taken off for the generator potential transformers, whence small wire leads run in conduits to the instrument board in the operating gallery), then to main generator circuit-breakers which are placed on the feeder gallery next above the basement, with their backs to the engine room columns.

The three bus-bars of the working bus are placed in a three-story structure of brick and alberene stone along the north side of the gallery, the auxiliary bus being in a similar structure along the south side and directly opposite the main bus. Ranged along the inner side of these structures, and facing each other, are two lines of oil circuit breakers, the two smaller ones on each line directly opposite each other being generator selector breakers, and the two larger ones being the feeder group selector breakers. These successive lines of feeder selector switches are joined under the floor by group bus-bars, there being a selector switch at each end of this group bus, which can be joined to either the main or auxiliary station bus.

The main generator switches are connected to similar sets of cross-connecting bus-bars, joining the generator selector switches, thus enabling any generator to be thrown in on either set of bus-bars by closing the proper selector switch. The generator oil switches are 4-pole, in order to give an extra connection to the neutral point of the generator winding. All the other oil switches are 3-pole.

Besides the oil switches there are also installed disconnecting hook type switches, to be opened and closed by hand, for isolating various parts of the system of connections when not in use, or while being inspected. These are mounted on heavy porcelain pillars placed in small compartments built into the brick bus structure.

In order to get indications of the voltage across the main bus-bars, bus potential transformers are provided, mounted in brick and alberene stone compartments on top of the bus structure. Leads from these transformers run to the instrument board in the operating gallery.

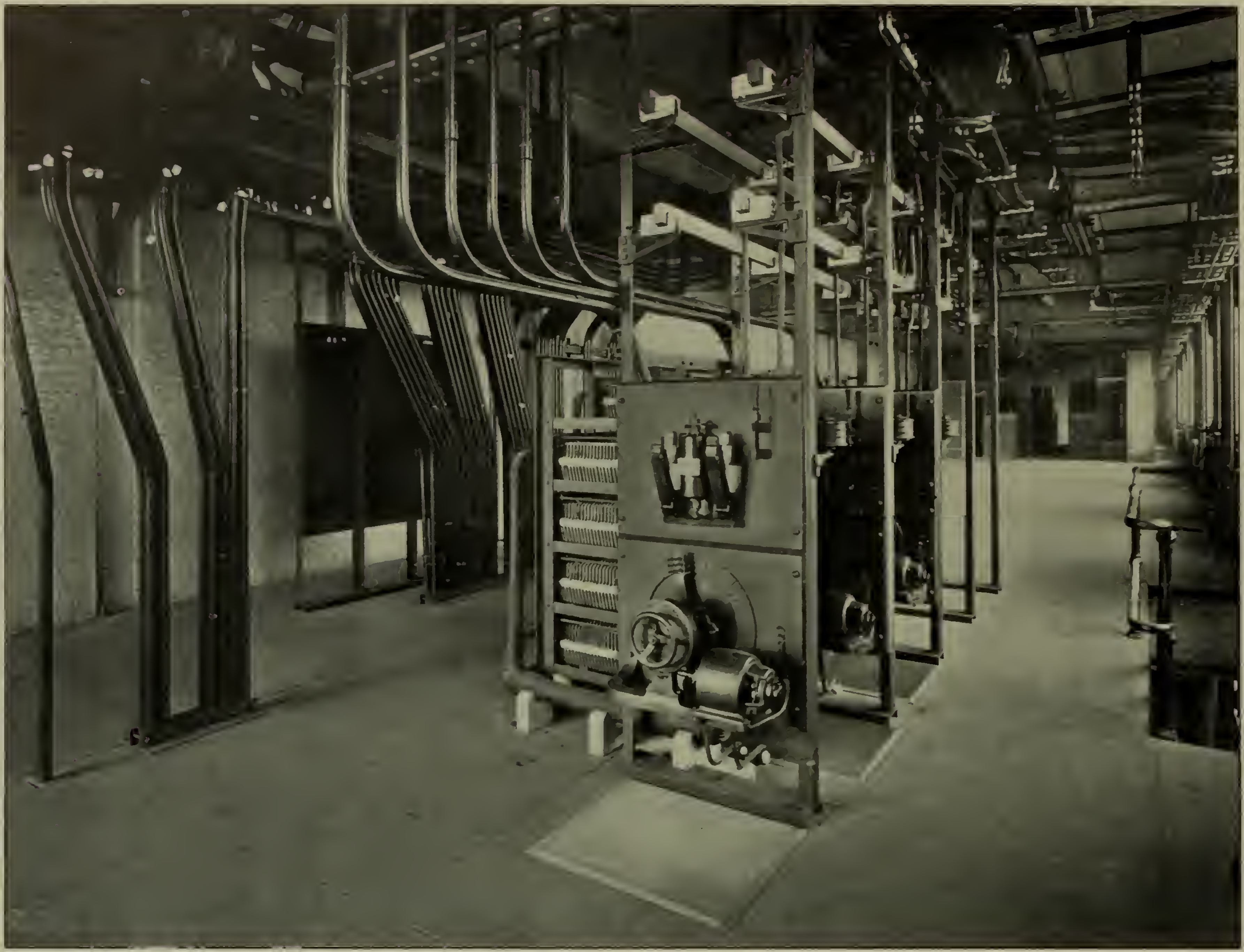
THE FEEDER GALLERY, SHOWING THE OIL CIRCUIT BREAKERS FOR FEEDERS AND GENERATORS

From the feeder circuit breakers on the feeder gallery the separate cables pass down through the floor, still in brick septums, to a few feet below the basement floor level, where they are spliced to the conductors of the three-phase cables, which pass into the outgoing ducts laid in the floor of the basement gallery. Thence they are conducted to the distributing manhole at the commencement of the conduit line leading toward the sub-stations.

ELECTRIC CONTROL APPARATUS.

The above described system of switches, bus-bars, and regulating or other auxiliary apparatus is all controlled from the operating room at the east end of the third or operating gallery. This location at the east end of the present engine room will be opposite the centre of the completed engine room when the building is extended to accommodate the final installation. This gallery is about 13 feet above the main engine room floor, and projecting from the generating room is an overhanging observation balcony that gives a good view of the whole engine room. Mutual intelligence for the proper operation of the turbines and the controlling switches is commonly interchanged between the engine room floor and the operating gallery by means of a system of visual

BUS STRUCTURES AND SELECTOR SWITCHES



THE BUS GALLERY, SHOWING THE GENERATOR RHEOSTATS AND AUXILIARY WIRING

signals. The instruments are all operated from current derived from shunt potential transformers and series transformers, suitably located in the leads from each machine.

The feeder switchboard consists of three vertical panels, each containing appartus for the control of six feeders and two feeder group selector switches, one of the latter running to each bus, and enabling the group of feeders on that panel to be put on either bus at will. Each of the three panels is at present equipped, however, with only three sets of feeder control apparatus, space being left for the remaining three when the installation is completed. The complete outfit of instruments on a completed feeder panel designed for six feeders is as follows:—Six ammeters; six controllers for feeder circuit breakers, with two indicating lamps for each one; two controllers for the group selector circuit breakers, having two indicating lamps each.

The exciter and switchboard is placed to the left of the generator instrument board with several blank panels intervening. It is designed to control the output of two steam exciters, three motor-driven exciters (of which only one is now installed), and the storage battery, which is provided as a relay for excitation and other important auxiliary purposes.

A separate auxiliary switchboard controls the supply to all the various direct-current motors and the lighting system throughout the station, and from it is also supplied the current required for electrically operating the generator selector and feeder oil switches, whether automatic or not.

ENGINE ROOM SIGNALS.

A very complete system of signals for intercommunication between engine man and electrical operator has been installed, consisting of a number of illuminated signals grouped together and located at a point visible from all parts of the engine room. These are worked from the operating gallery after the engine man's attention has been obtained by means of a whistle signal.

A system of return signals operated from the engine room floor and showing in the operating gallery, enables the engine man to show the electrical operator that his signals have been understood, and the two systems together supply all necessary communication between the two operating floors. A large synchroscope, visible from all parts of the engine room, has been installed, so that by watching it the engine man is informed as the generator approaches synchronism and is switched into service.

CONCLUSION

The first work of clearing the site began on September 15, 1903, and the excavation on October 20. The first turbine was started January 16, 1905, and the high-tension current first turned into the transmission lines April 27, 1905. Current was furnished for testing cars on May 13, and on July 26, 1905, the line be-

tween Flatbush terminal and Rockaway Park, the first section of the Long Island Railroad to use the new motive power, was permanently changed from steam to electrical operation.

The station was planned and built by Westinghouse, Church, Kerr & Co., engineers for the Pennsylvania, New York & Long Island Railroad Company, which is the organization through which the Pennsylvania Railroad is carrying on its New York extension work. The design and construction were under the charge of Mr. George Gibbs, chief engineer of electric traction of the road, and under the general supervision of the mechanical and electrical advisory committee, New York Extension, a committee composed of officers of the Pennsylvania Railroad Company.

The Dalrymple Report on the Municipalization of Chicago's Street Railways

THE report of James Dalrymple, general manager of the Glasgow Corporation Tramways, regarding the municipal control of Chicago's street railways, has been made public. It is well known that Mayor Dunne, to whom the report was made nine months ago, refused to send it to the City Council. The latter then sent a request to Mr. Dalrymple for a copy, which was made public when received.

Mr. Dalrymple says in the report that there are many questions which tend to make the position a very difficult one for a municipality to deal with. There is, for instance, the unsatisfactory state of the various franchises that have been granted to the street railway companies. If these long franchises are upheld, it would be very difficult,—almost impossible,—for the city to purchase these.

Presuming that the city is able at a satisfactory figure to purchase the present undertaking, including the franchises, there would undoubtedly be a very grave danger in attempting to operate what would be the largest street railway undertaking in the world, without making a very radical change in the methods usually employed in carrying on municipal work by the cities of the United States.

If the street railway companies object, the city is advised to start a municipal system without delay.

In regard to a reasonable settlement, the report advises that the present companies be merged into one, so that the whole may be operated as one complete system. All claims under the ninety-nine-year franchise must be waived. There must be one fare and no central loops. The use of trailer cars should be discontinued.

The present equipment would require in a great measure to be thrown into the scrap heap, the whole work of reconstruction being carried out at the sight and to the satisfaction of the city officers. The new operating company might be allowed a fixed time in which to have the whole system put into complete order and afterwards have a franchise for, say, 20 years, the municipality having the right, say, every 5 years, to take possession on stated terms.

A percentage of the gross annual earnings should be handed over to the city treasury to be used for specific purposes, say, the upkeep of the streets; full and detailed statement of all incumbent expenditure, both on account of capital and revenue, should be produced annually by the operating company to the city officers.

Mr. Dalrymple says, further, that he would be very sorry were the city forced to start its own municipal system, as, speaking generally, from his knowledge and experience of what it means to operate a municipal street railway system, the municipalities of the United States are not quite ready to successfully undertake this work.

Regarding the management of a municipal street railway system, he recommends that the street railway department be managed by a small committee of the City Council, to be chosen irrespective of politics, and that the whole internal management be placed under one permanent officer.

No other system than the overhead trolley should be used, and power should be purchased at first, a central high-tension plant with substations being erected later.

In notes appended to the report are given instructions as to the "administration of the street car service by a municipality."

Large Gifts to the Building Fund of the American Institute of Electrical Engineers

THE chairman of the land and building fund of the American Institute of Electrical Engineers announces some very large and important contributions to this fund, the object of which is to raise $200,000 for the land on which the United Engineering Building, given by Mr. Carnegie, is now being erected. The total cost of the land is $540,000, and the obligation is divided between the electrical, mechanical and mining engineers.

Clarence H. Mackay, president of the Postal Telegraph-Cable Company, has given $5000 to the fund, accompanied by the expression of his interest in the building as a center, the facilities of which will be available to the various bodies of telegraphers. U. N. Bethell and J. J. Carty have advised the committee, of which they are members, on behalf of the American Telephone & Telegraph Company, the Western Electric Company, the New York & New Jersey Telephone Company, and the New York Telephone Company, that these corporations have jointly contributed $25,000 to the fund, in view of the great benefits that the existence of this new engineering center will confer upon the electrical arts and upon their employees in the widening field of telephone engineering.

Other notable gifts to the fund are $1200 from E. W. Rice, Jr., and $500 from T. D. Lockwood. A number of subscriptions of less amounts have been received from the Institute membership at large, and in this manner the fund has now reached the total of over $130,000, or two-thirds of the required amount. With the campaign it has already inaugurated, and the plans now maturing, the committee is hopeful of having the entire sum pledged before the Institute moves into its new home.

Nominations for Institute Election

AT the meeting of the board of directors of the American Institute of Electrical Engineers held in New York on March 23, the following list of "directors' nominees" was made up to be voted on at the coming election:—

For President—E. Wilbur Rice, Jr., of Schenectady, N. Y., or Samuel Sheldon, of Brooklyn.

For Vice-Presidents—A. H. Armstrong, Schenectady; H. H. Humphrey, St. Louis; F. G. Baum, San Francisco.

For Managers—Paul Spencer, Philadelphia; P. M. Lincoln, Pittsburg; A. M. Schoen, Atlanta; J. J. Carty, New York.

For Treasurer—George A. Hamilton, New York.

For Secretary—R. W. Pope, New York.

Three vice-presidents and eight managers hold over.

A single-phase traction system is to be constructed between Locarno and Bignasco, in Switzerland, a distance of 22 miles.

American Institute of Electrical Engineers

Papers at the March Meeting at New York

At the March meeting of the Institute in New York, three papers were presented. The first paper was by J. B. Taylor, on "Some Features Affecting the Parallel Operation of Synchronous Motor-Generator Sets." The phrase "synchronous motor-generator" was used to designate an alternating-current synchronous motor directly connected to an alternating-current generator. The author pointed out some of the details of construction, connections, and methods of operation that need to be considered in order that a desired division of load will result when such units are operated in parallel.

The most common use of motor-generator sets is to effect a change in frequency, so that standard lighting apparatus, alternating-current arc lamps, etc., may be operated at 60 cycles from a 25-cycle system, designed primarily for railway or power purposes. Such sets are also used as a means of interchanging power between systems already established and operating at different frequencies. The operation of the single-phase railway motor calls, in some cases, for a motor-generator set with inverted frequencies; that is, a 60-cycle synchronous motor in connection with a 25-cycle generator.

The author then told of some of the difficulties with early installations in getting sets to take their proper share of the load when started up and thrown in parallel with others. The operation of a synchronous motor was described, and the requirements for equal or proportional division of load were discussed. By means of vector diagrams, the electromotive force of the bus-bars, the current, the induction drop and resistance drop in the generator, and the induced electromotive force, were shown for power factors of 100 per cent. and 70 per cent. The division of load between two 500-KW., 25-60-cycle sets and that among seven machines was shown by means of curves.

Methods of starting were next taken up. Synchronous motor-generator sets may be started by applying alternating currents, preferably at low voltage, to either end of the set. With this method there is no need of synchronizing as the term is ordinarily applied. It is, however, essential in some cases to make further manipulation to secure proper phase relations.

Many of these sets are provided with direct-connected exciters, and in some cases these exciters are used as starting motors. Another combination is the use of an induction motor connected to the set, and provided for the specific purpose of starting. Either of these last two methods requires synchronizing, and in some cases special or additional manipulations to obtain proper simultaneous phase relations.

The author then described the methods employed to secure proper phase relations at both ends of the set, in use by the Chicago Edison Company, the Fonda, Johnstown & Gloversville Railway Company, and the Milwaukee Electric Railway & Light Company.

Data were given of a number of synchronous motor-generator sets, showing the cycles, phases, poles, and revolutions of both motor and generator, with the chance of the generator phase coming right when started by the synchronous motor. The table also showed the change in phase positions obtained by changing the connections. In a second table, data were given to show the connections for each of the different positions.

The author then dealt with several other features in the operation of synchronous motor-generator sets, saying in conclusion that the present general tendency toward extension and consolidation means that more and more systems will touch and overlap their neighbours, which may have started at different frequencies. We can, therefore, look for an increasing use of the synchronous motor-generator-set.

The next paper was by S. B. Storer, on "The Relation of Load Factor to the Evaluation of Hydroelectric Plants." The author first discussed the effect of the load factor and the nearness of the load on the price of current to the consumer.

It was generally conceded that the only object in developing a water power is to generate electrical energy at a cost much below that of generating it in any other way. A general method to be followed for comparing the cost of generating hydroelectric power with that from coal or gas was shown graphically in the curves given herewith. Figs. 1 and 2 are made respectively for both steam plants and hydroelectric plants, and show the cost of production per horse-power per year with relation to the load factor.

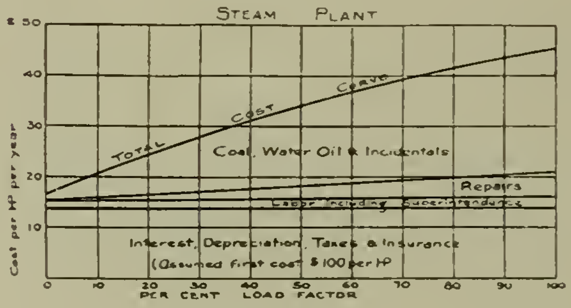


FIG. 1

In neither of these cases is the value given from an actual installation, but is merely an approximation indicating the general conditions as they might exist in any well-built power house of a rated capacity of from 5000 to 50,000 horse-power. The principal difference between the two curves is due to the introduction of the variable items of coal, water, and labour in the steam plant, while

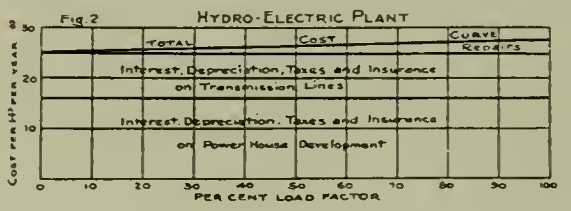


FIG. 2

the fixed charges in both cases form the base of the area included under the curve.

As usual, the fixed charges include interest, depreciation, taxes, and insurance. With hydroelectric plants the operating expense is so nearly constant as also to become practically a fixed charge. The item of repairs is really the only variable one in the curve, this generally being considered as increasing in direct proportion to the load factor.

By superposing the two curves, as shown in Fig. 3, it will be seen that

in this assumed instance they cross each other at 25 per cent. load factor, the cost per horse-power per year being identical at this point. At load factors less than 25 per cent., the steam plant has the advantage, and hydroelectric power must be sold at a loss in order to be competitive. At all load factors above 25 per cent., however, the advantage lies with the hydroelectric plant.

The relative value of the two may be obtained by considering the variables—coal, water, and labour—of the steam plant as the equivalent at

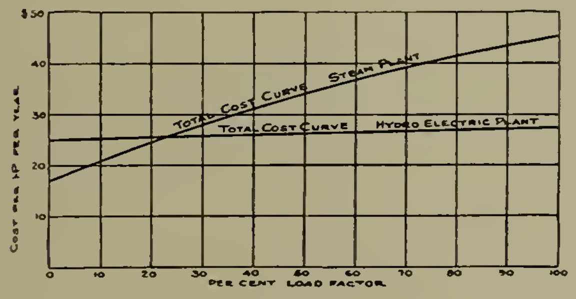


FIG. 3

any given load factor, of a fixed charge, and by capitalizing this at a rate that will include interest, taxes, and depreciation, and adding it to the first cost of the steam plant, we can thereby obtain an approximate value of the hydroelectric development.

Making a comparison in another way, the water operating the hydroelectric plant can be made a variable, following the line taken by the coal of the steam plant, and by capitalizing the difference between the two curves, an approximate value of the potential energy of the water can be obtained. Due consideration must be given to the fact that at load factors of less than 25 per cent., this capitalization is negative and must be taken from the actual cost of the plant, so that it is only at load factors above 25 per cent. that it has any real value. In addition, the curve representing power cost from the steam plant must be discounted by an amount corresponding to whatever reduction must be made in hydroelectric rates to effect its sale.

The conclusion is that in all places where the flow of water is constant throughout the year the load factor determines the earning power and hence establishes the value of any plant. Where an intermittent or insufficient supply of water may be stored and used during times of peak loads at a rate much higher than the normal flow of the stream, the earning power is not dependent on the load factor to so great an extent. Such hydroelectric plants, however, are generally of small capacity, adapted for lighting purposes only, and are to be considered as an exception to which the above method of evaluation will not apply.

In "Notes on the Design of Hydroelectric Power Stations," D. B. Rushmore discussed the subject with regard to the influence of load factor.

The factors entering into the design of a hydroelectric plant were first outlined and the relation of station capacity to stream flow was next dealt with. The author said that the majority of plants have a rated generator capacity between maximum and minimum stream flow. As at Niagara, the plants may be below stream flow at all times, and some developments, especially when replacing steam plants which are held as a reserve, may have a rated capacity of approximately maximum flow.

The number of plants to the system and the distribution of plants on different watersheds materially affect conditions of design and operation. The presence or absence of steam or water auxiliaries, and the use of hydraulic or electrical storage, also influence the design, while the class of service has an important bearing on the system of control.

Load factor was defined as the ratio of average output to maximum output, with the qualification that no definition is satisfactory for all classes of load without explanation. The influence of the kind of load on the load factor was outlined.

In discussing the hydraulic features, the great problem of hydraulic development was said to be to transform the stream flow to correspond to the load curve. In connection with this, the design of water conductors and the type and number of wheels were briefly dealt with.

With regard to the proper subdivision and rating of the elements of plant design in adapting the plant to definitely assumed load conditions, the principal features — reservoirs, ditches, flumes, pipes, wheels, generators, transformers, and lines—were next discussed.

The cost and value of efficiency in power-plant designing, the author said, is an important but not clearly understood subject. The rough approximation usually made is to compare the selling price of the increased output with the interest charge on the greater cost. Where the saving in energy can be sold, a higher efficiency in water conductors means a greater output, so that the investment charge for the gain in power is greater than usually considered. This is true of all parts of the chain of energy transformation.

In conclusion, the author dealt briefly with the storage of water for plants with a limited water supply, and the use of auxiliary steam plants for increasing the capacity of the water-power installation.

DISCUSSION.

In the discussion following, W. L. Waters said that he had been very much interested in Mr. Taylor's paper, and was quite impressed with the very simple operation with which he illustrated the working of the generator. The speaker's personal experience, unfortunately perhaps, has not been quite in line with the author's experiments, and they have not given quite the simple results that one would expect from a perusal of the paper.

He had one installation which worked exceedingly well, where he could distribute the load just as he wanted to have it, but in another installation, which was apparently just as perfect as the first, he could not get it to work satisfactorily at all; it gave all kinds of trouble, even after he took into consideration the fact that the connections were perhaps wrong,—and they were changed,—and that the poles were not in line.

In some cases that he had come across, where a 500-KW. machine was running, very good results were obtained, but when it is connected with a 250 or 300-KW., it may not be possible to vary the percentage which it takes by varying the excitation; that is, it may or may not be, and, as the further load comes on the machine, it will be troublesome. The speaker had not been able to find out what the exact reason for that is, but there was one point that he thought had something to do with it, perhaps, and that is the power factor of the load carried on the generator. Most of these frequency changes, 25 to 60, run very often on single-phase distribution instead of three-phase distribution, the power factor being different on all phases.

Referring to Mr. Taylor's table of data, in taking into account the reaction inside of the generator, the author regarded the inductive effect as being produced in exactly the same way as if a constant induction were in synchronism with the generator, which gives the factor designated as demagnetizing drop. The speaker thought that a pure assumption, and that it was not based on fact. With two machines in which the angle might be the same, and which ran the same, the power factor may or may not be the same, which might make quite a considerable difference in distributing the load.

Again, the author pointed out the very important fact that when you throw in the incoming frequency changes it is not in phase with that of the bus-bar. The station operator often thinks when he sees the difference in phase that that is the cause of the trouble, and he puts it down to something being wrong. It should be found out whether the poles are right or wrong, and the only way to do that is to throw them together on no load, because when they are both together under exactly the same conditions, it can be seen whether they will phase or not.

As regards the starting, the speaker thought the method of starting the two pointers very much superior to the method shown of reversing the poles, for, although the modern machine will stand that, yet it is putting an unnecessary strain on the machine. The question of frequency changes is one in which practice is more valuable than any theoretical explanations that he had seen of it. Nevertheless, he believed that they were all greatly indebted to Mr. Taylor for his very simple and lucid explanation of this subject, which would, at least, give something to work upon in the future.

As there was no discussion on the other papers, Mr. Taylor replied to Mr. Waters, saying that his principal objection seemed to be the starting of the motors, using a reversible field switch. He thought a little consideration would show that the objection was not valid. Every motor has to go through the process of slipping, that is, it has to lock into position, and when the field is thrown on one, it has to slip a pole. Furthermore, in practical operation that is done on the starting, so that the increase in the current and the strain on the machine is not very great. Every machine must do it, and this simply means that you may have to set it in two or three times in succession, and it is built so that it will stand the work year in and year out.

Electrically heated retorts are better adapted than those formerly used for the production of phosphorus, inasmuch as cheaper crude materials may be employed, the temperature is more easily regulated, a purer product is obtained, and the use of sulphuric acid is avoided, which, in the old process, vigorously attacked the retorts, causing leaking and loss of output. In Germany, where already one-third of the output is obtained by the electric method, iron retorts, lined with fire-clay, and internally projecting carbon electrodes are used.

Single-Phase Equipment for the Central Illinois Construction Co.

MENTION has been made in these pages of the single-phase traction equipment recently ordered from the General Electric Company, of Schenectady, N. Y., by the Milwaukee Light & Power Company. The equipment for another similar system, ordered from the same company, is that for the Central Illinois Construction Company. On account of the extended territory which this company eventually plans to cover, as well as the new construction now under way, the question of the proper system of distribution has called for a most careful investigation. As a result, single-phase, alternating current has been adopted for the additional 80 miles of track being constructed and its use is anticipated on future extensions. The portion of track to be so equipped consists of two 40-mile lines, one connecting Bloomington and Peoria, the other lying between Springfield and Lincoln.

The present equipment of the Central Illinois Construction Company is direct current, consisting of heavy, suburban-type cars, equipped with four 75-H. P. motors, and their local demand for power is considerable when accelerating or when operating on grade. The cars for the new extensions are still heavier, and it is evident that the question of secondary distribution is one of great importance when such large equipments are used over a system so extensive. There is now high-tension distribution from the Riverton station at 13,200 volts, but this line is being changed to 33,000 volts, and the latter station will be supplemented by a second power house located in Peoria, with a common 33,000-volt transmission line connecting the two stations.

Ten compensated-motor car equipments are to be furnished by the General Electric Company, together with necessary sub-stations, overhead line material, generating station equipment and the like. Each car equipment consists of four 75-H. P. motors with Sprague-General Electric system of multiple-unit control adapted for use on alternating-current circuits. These are so arranged that they will permit tap control when running on alternating current, and series-parallel resistance control when running on direct current. In addition to the motors and control apparatus, complete alternating-current-direct-current air compressors and straight air-brake equipments will be installed, as well as arc headlights adapted for use on 25-cycle alternating current. The trolley will be of the pantagraph type with rolling contact, raised and lowered by compressed air.

The equipment just outlined will take care of the passenger service, but for hauling freight the operating company will employ a single-phase locomotive equipped for service on the same roads as the regular motor cars. This locomotive will be of the eight-wheel type, equipped with four 125-H. P., compensated, alternating-current motors. The total weight of the locomotive complete will be 50 tons, with a draw-bar pull of 20,000 pounds. It will haul its train at a speed of 20 miles per hour, with the current supply at 3300 volts and 25 cycles. In common with the motor cars for passenger service, the locomotive will be equipped with the Sprague-General Electric multiple-unit control for operation on both direct and alternating currents. It will also be supplied with a complete air-brake equipment.

To furnish additional power for this new rolling stock, the present generating station at Riverton will be supplemented by a 2000-KW. Curtis steam-turbine unit, furnishing current at 25 cycles, and the new power house at Peoria will be equipped with two 2000-KW. Curtis turbine units. Additional machines will be installed as soon as other lines, now under consideration, are constructed. The generator and high-tension distribution system will be three-phase and will feed the present rotary-converter sub-stations, and also the 80-mile section of track operating with alternating current.

The alternating-current trolley will be 3300 volts, of the well-known catenary type. Four transformer sub-stations will feed the trolley. Each sub-station will contain two 200-KW., single-phase transformers with complete controlling high-tension and low-tension switchboard apparatus. They will be placed approximately 20 miles apart and are so arranged that trouble in any sub-station will automatically cut out that station without affecting operation on the rest of the line.

With a view of introducing electricity for domestic use along the line of the Kokomo, Marion & Western Traction Company, in Indiana, President Marott, of the company, has secured Mrs. A. V. Sanborn, of St. Louis, to deliver lectures on cooking by electricity and demonstrate to the farmers' and villagers' wives how successfully and economically electricity can be used in the home.

Electrical and Mechanical Progress

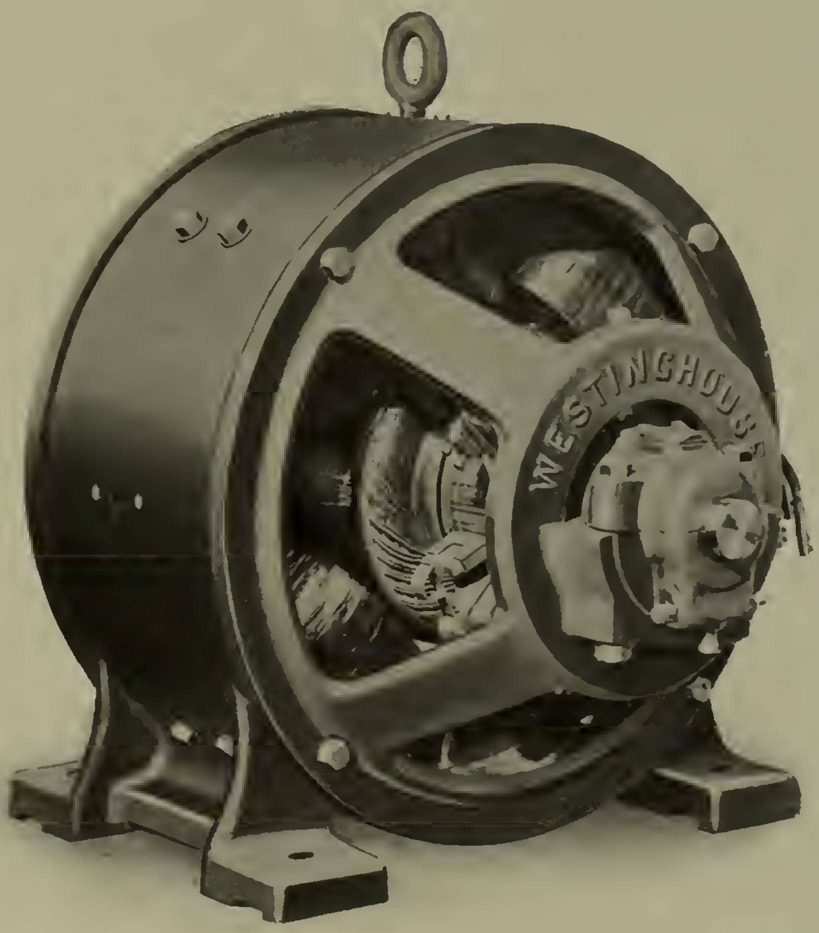
Westinghouse Auxiliary-Pole Motors

IN many classes of work a wide speed variation is required, and to meet the demands of such service the Westinghouse Electric & Manufacturing Company, of Pittsburg, has developed a line of direct-current motors having a speed range of 4 to 1 on a single voltage. This wide speed variation is obtained by field control, and it is claimed that the type SA motors compare favourably in every respect with the best direct-current constant-speed machines.

The new motors are exactly similar mechanically and electrically to the Westinghouse type S motors, except for the addition of auxiliary poles and coils. These are introduced in order to control the field form during the variation of field strength necessary to obtain so wide a range of speed. The cast-steel poles with machine-formed coils are placed midway between the main poles and securely bolted to the frame. The construction is very simple and introduces no complications whatever, nor does it make difficult the removal of the main poles and field coils, as is evidenced by the fact that an auxiliary pole and coil can easily be taken out, without in any way disturbing the main field winding, by simply disconnecting the coil connections, withdrawing the bolts which hold the pole to the frame and sliding the pole and coil out parallel to the shaft.

The auxiliary field winding is connected in series with the armature, and therefore produces a magnetizing effect which is proportional to the armature current. The auxiliary coils are placed as close to the armature surface as mechanical considerations will permit and their turns are concentrated at that point. This arrangement adds materially to the performance of the motor, as it applies to the corrective influences of the auxiliary winding directly at the points where the distorting effect of the armature current is strongest.

This arrangement is much more effective, it is claimed, than the distribution of the ampere-turns along the length of the auxiliary poles. The magnetic field of the auxiliary winding acts in direct opposition to that produced by the armature current. The resultant field is made up of three components—that due to the shunt winding, that due to armature reaction, and that due to the auxiliary windings. The field distortion usually produced by armature reaction is therefore overcome and the shape of the magnetic field at the



AN AUXILIARY POLE MOTOR BUILT BY THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, PITTSBURG, PA.

point of commutation is maintained as formed by the main poles, and good commutation is made possible over a wide range of speed.

These motors are shunt wound, and for each point of the controller, give a definite speed, which is nearly constant for all loads. Heavy overloads may be momentarily carried without injurious sparking. The motors are reversible without danger and without readjustment of the brushes, and, as the armature and auxiliary windings are connected permanently in series, it is only necessary to change the external armature connections to reverse the directions of rotation.

These motors, it is further claimed, develop their full rated output throughout their entire range of speed. They will carry full rated load at any speed within their range for six hours with a temperature rise not exceeding 40 degrees C. in armature and field, and not exceeding 45 degrees C. on the commutator, as measured by the thermometer. At all loads and all speeds, it is claimed, commutation is excellent, and an overload of 25 per cent. may be carried for one hour without injurious sparking. All motors are thoroughly ventilated, running cool and at a uniform temperature. Their efficiency is high and their speed regulation practically exact. With the exceptions noted, type SA motors are mechanically identical with the type S, and corresponding parts are interchangeable.

An Automatic Recorder of the Carbon Dioxide In Chimney Gases

In a paper on "Power Plant Economics," read at the January meeting of the American Institute of Electrical Engineers, H. G. Stott told of the added economy obtained by the use of an apparatus for recording the percentage of CO_2 in chimney gases.

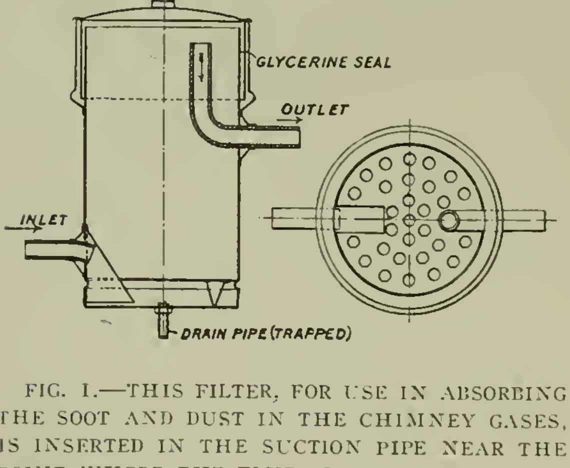


FIG. 1.—THIS FILTER, FOR USE IN ABSORBING THE SOOT AND DUST IN THE CHIMNEY GASES, IS INSERTED IN THE SUCTION PIPE NEAR THE POINT WHERE THE FLUE IS TAPPED

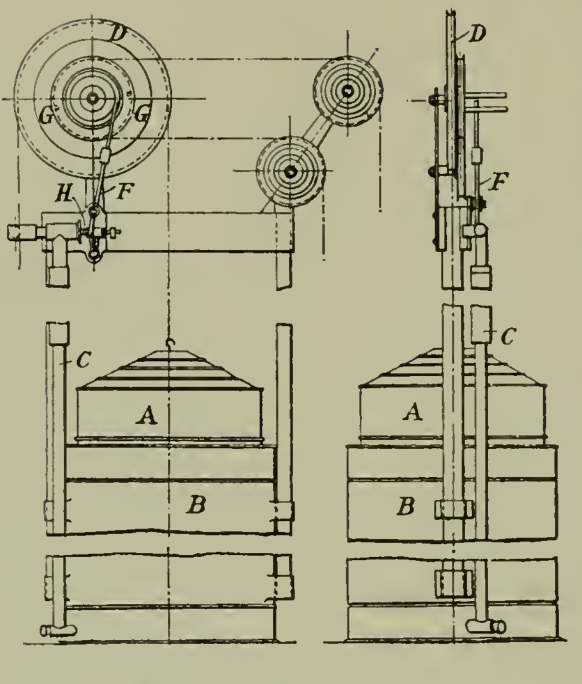


FIG. 2.—MOTOR USED IN OPERATING THE APPARATUS FOR RECORDING THE CARBON DIOXIDE IN CHIMNEY GASES

A description of the apparatus was given in a recent issue of "Engineering," of London, from which the following particulars are taken: Its working is based on the well-known fact that a solution of caustic potash absorbs carbon dioxide, this property being made use of in the following way: A quantity of the flue gases is pumped through the recorder, and a certain portion of the gases is bottled up, measured, and passed through a solution of caustic potash, which absorbs the whole of the CO_2 gas contained; and this quantity—which is, of course, a certain percentage of the whole—is determined, and is recorded on a card which is moved by clockwork around a revolving drum.

Each record is represented by a vertical line of a certain height, depending on the percentage of CO_2 in the gases. As the process is repeated every two to five minutes, a series of vertical lines is formed, and a line joining the tops of these gives a curve which represents the variations in the amount of CO_2. Where it is desired to test several boilers by means of one recorder, the latter may be connected to each furnace by means of a system of tubes, and the furnace to be tested may be switched on to the recorder, when desired. It is advisable, however, to have one recorder for each furnace.

Fig. 2 shows the motor for operating the mechanism. It is placed above the cabinet containing the recording apparatus, and consists of a float or bell *A*, which works up and down in water and oil contained in the tank *B*, the water and oil forming a seal. The float *A* is connected to the chimney or flue by the pipe *C*, which enters the tank *B* at the bottom, and extends upward inside to above the level of the water in *B*. A cord or wire is led from the top of *A* over the pulley *D*, and down to a bottle *E*, shown in Fig. 4.

The float *A* is balanced, so that it will just rise when the communication with the chimney is closed. When, however, the communication with the chimney is opened, the suction of the draught causes the float *A* to fall. The reversal of motion is obtained by means of the lever *F*, which is actuated in the following way: As the float *A* rises it turns the pulley *D*, and in so doing brings one of the pins *G* against the lever *F* and forces it over, the lever, when it reaches the vertical position, falling to the right by its own weight.

This action moves the valve *H*, and opens the communication between the pipe *C* and the flue. The float *A* then descends, and the opposite pin on the pulley *D* forces the lever *F* back to the left, thus, through the valve

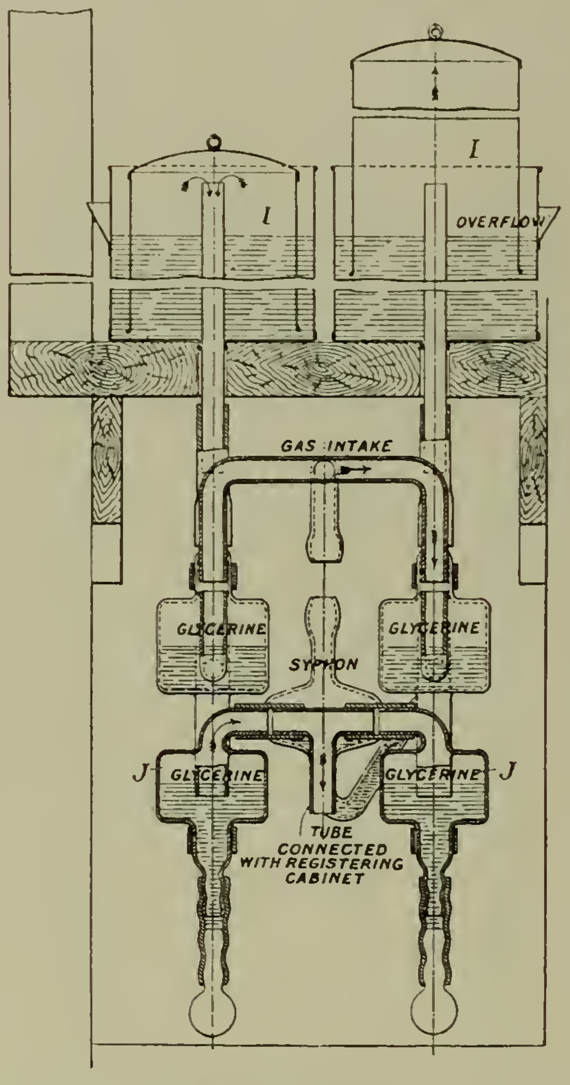


FIG. 3.—THE PUMP AND TUBES USED IN THE APPARATUS

H, closing the communication between the float *A* and the flues, and opening it to the atmosphere. The float again descends and the operation is repeated.

The motion thus given to *D* is utilized to work two pumps shown

at I, I in Fig. 3. These pumps are designed on the same principle as the motor A. The motion of the pulley D is also utilized to raise and the lower bottle E, Fig. 4, the object of which will be presently understood.

The gases which are to be analyzed are drawn from the flue through a system of tubes J, J, Fig. 3, and they then pass into the recording cabinet by the tube K, shown in Fig. 4. The bottle E, which is in communication with the system of measuring tubes L by means of a flexible pipe M, is filled with a mixture of glycerine and water in proportion of one part of the former to three of the latter. When the bottle rises, the liquid in the tubes L rises at the same time, and, when it reaches the point N, closes the inlet for the gas from K. Contained in L is an inner gas-essape tube O, which is connected with the atmosphere by the pipe P. When the liquid reaches the bottom end of the tube O, exactly 100 cubic centimetres (61.1 cubic inches) of flue gases are contained in the glass vessel L.

As the bottle E rises farther, the gases in the vessel L are gradually forced through the tube R into the vessel S, which contains a solution of caustic potash of 1.27 specific gravity. The whole of the 100 cubic centimetres of the gases has been forced over when the liquid in L reaches the mark Q, this being the point at which the motor reverses. This reversal is automatically brought about by the two studs G, G on the pulley D before alluded to, the valve H being also automatically opened when the bottle E is at its highest point, or when the liquid touches the mark Q.

The moment the gases come in contact with the caustic potash in the vessel S, the CO_2 is absorbed. The pressure of the remaining gases displaces the potash in S and forces it up the tube T into the air-vessel U. When the potash reaches the bottom of the tube V, which connects U with the atmosphere, a certain quantity of air is bottled up in the space above. When the potash has risen to the bottom of tube V, it has driven 60 cubic centimetres of air at atmospheric pressure out through the tube V, but, on the potash rising farther, it compresses the air in the upper part of the vessel U and raises the bell W, which floats on a glycerine seal. In the bell W is inserted an inner tube X, which is closed at the lower end. To raise W to the point where the lower end of X touches

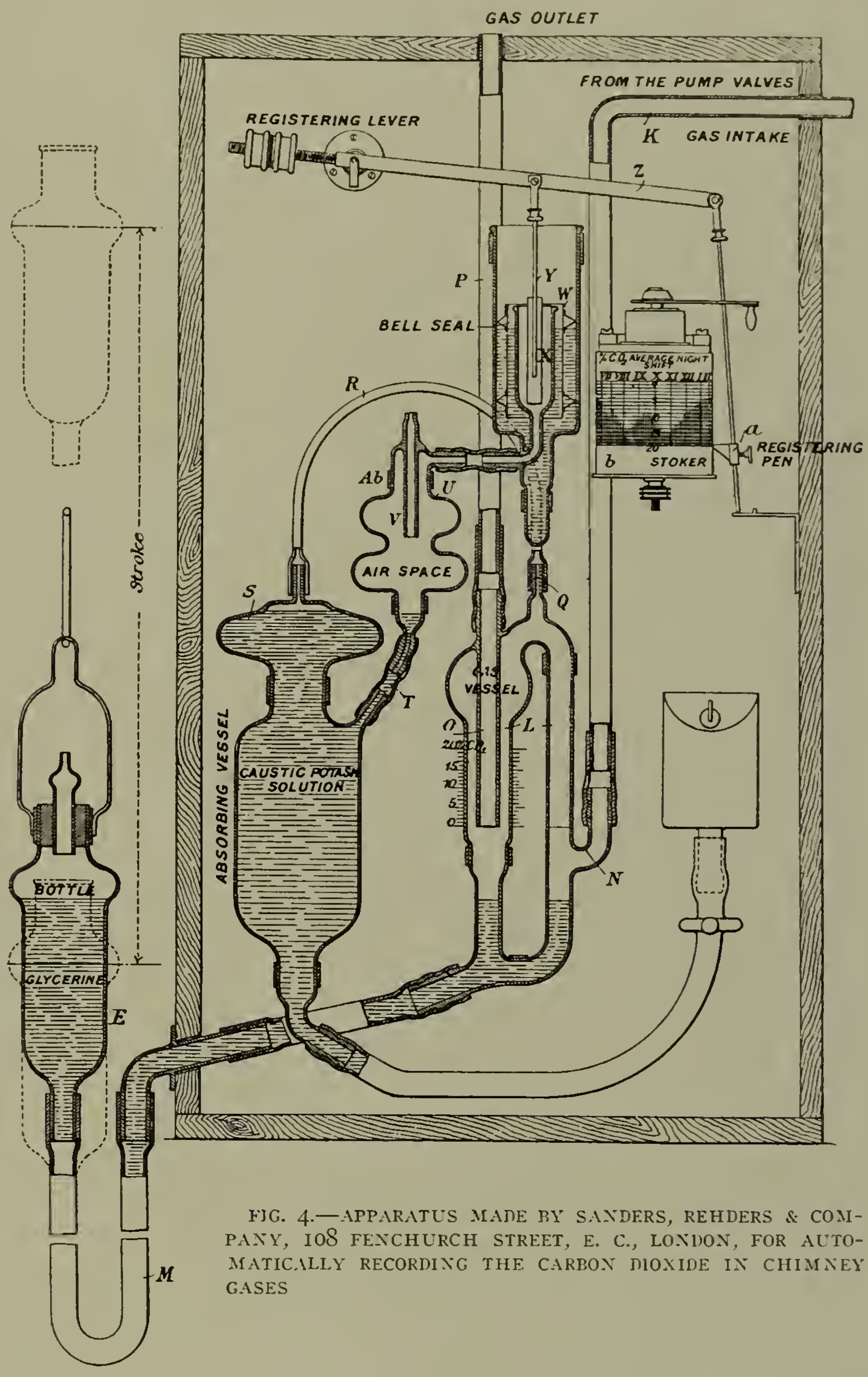


FIG. 4.—APPARATUS MADE BY SANDERS, REHDERS & COMPANY, 108 FENCHURCH STREET, E. C., LONDON, FOR AUTOMATICALLY RECORDING THE CARBON DIOXIDE IN CHIMNEY GASES

the rod Y, 20 cubic centimetres of air are taken up, and the remaining 20 cubic centimetres (making up the 100 cubic centimetres) serve to raise the registering lever Z. To this lever is attached the pen a, which draws lines on the chart carried on the drum b.

The chart is calibrated in per cents., from 1 to 20, and the time is marked on it. For every per cent. of CO_2 absorbed, 1 cubic centimetre of air less is displaced, and the registering lever is made to rise 1 per cent. less on the chart. It will, therefore, be seen that when there is no CO_2 present, the pen will rise to the top of the chart.

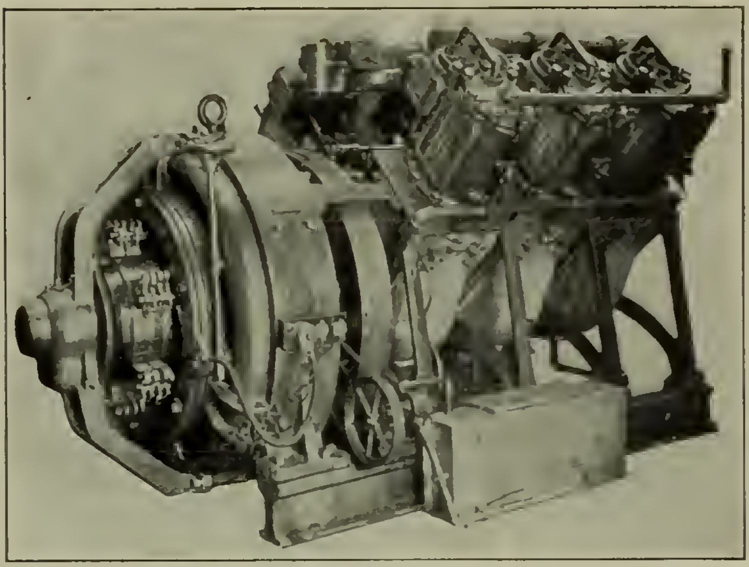
The apparatus is self-contained and very compact. It is 6 feet high, 3 feet wide and 2 feet 6 inches deep. It may be erected on any convenient situation; but it is advisable that this should be as free from dust as possible, and not too hot. If it be placed within ten yards from the boiler, the suction gas pipe is ½ inch in diameter; but if the distance is greater than 10 yards, the diameter of the pipe is ¾ inch. The filter shown in Fig. 1, is inserted in the suction pipe near the point where the flue is tapped. The filter is filled with wood-wool, which absorbs the soot and dust contained in the gases. A lid, which dips into glycerine, covers the filter and prevents the escape of gas.

The apparatus is made by Sanders, Rehders & Co., 108 Fenchurch street, E. C., London.

The Philippine Island Telephone & Telegraph Company is now installing a modern telephone plant at Manila.

An Independent Electric System for Railway Cars

AN independent electric system for use on steam roads, to meet the competition of parallel electric lines, has been designed by the Strang Electric Railway Car Company, of New York. Briefly, the system is a combination of a gasoline engine, a dynamo and storage battery. The engine furnishes the power to run the dynamo and generate electricity for the motors that operate the car, and the storage battery, on the one hand, receives the surplus power from the generator when the load is light, and, on the other hand, furnishes the excess power required during acceleration and on steep grades.



THE GASOLINE-ELECTRIC GENERATOR IN THE CAR SHOWN BELOW

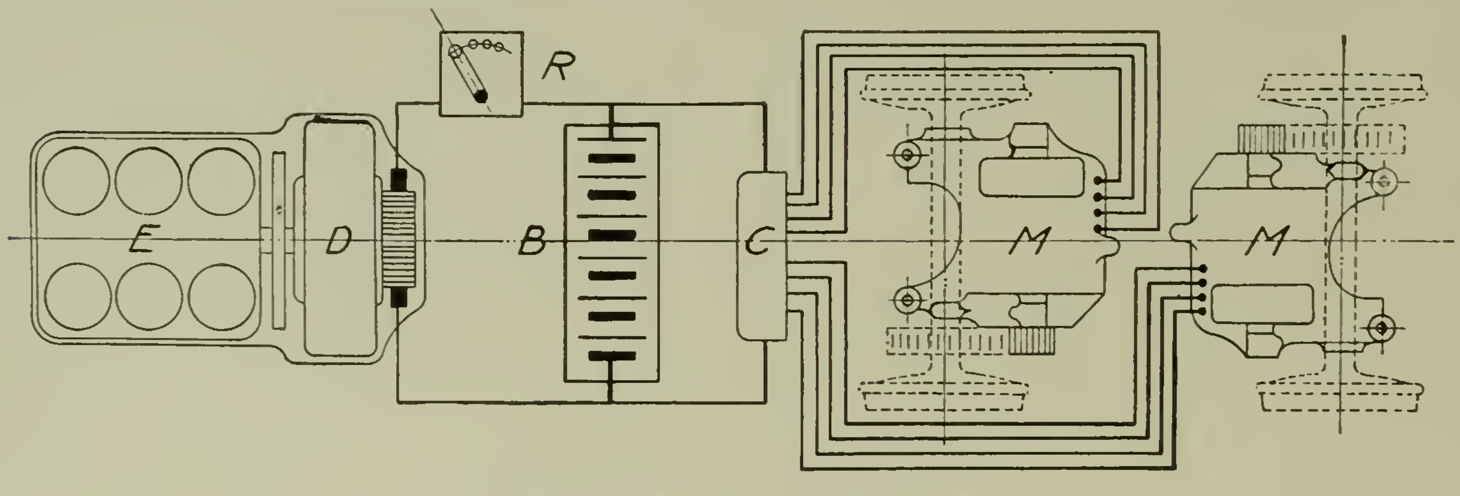
The special car, illustrated herewith, was built by the J. G. Brill Company, of Philadelphia, from plans and specifications furnished by the Strang Electric Railway Car Company, and is mounted on high-speed trucks, having rolled-steel wheels. Several more cars are now building, for use by the Missouri & Kansas Interurban Railway Company, over the Santa Fe trail from Kansas City, Mo., to Southwestern Kansas.

The great advantage claimed for the Strang system, is that it requires an engine only large enough to develop the average power used. It is of the 4-cycle type, with six 8 by 10-inch cylinders, and was built by the Strang Electric Railway Car Company, after plans of Lars G. Nilson, the company's engineer. To secure a short crank shaft and reduce vibration to a minimum, a partially-opposed cylinder construction was adopted, with three cylinders on each side, those on one side being at an angle of 90 degrees to those on the other. This arrangement is clearly shown in the illustrations. Accessibility of parts is an added advantage.

Though the bearings and wearing surfaces are larger than is customary, the entire weight of the engine has been reduced by using aluminium for covering parts where there is no strain. Cast-steel is used for the engine frame, and also the base to which it is bolted.

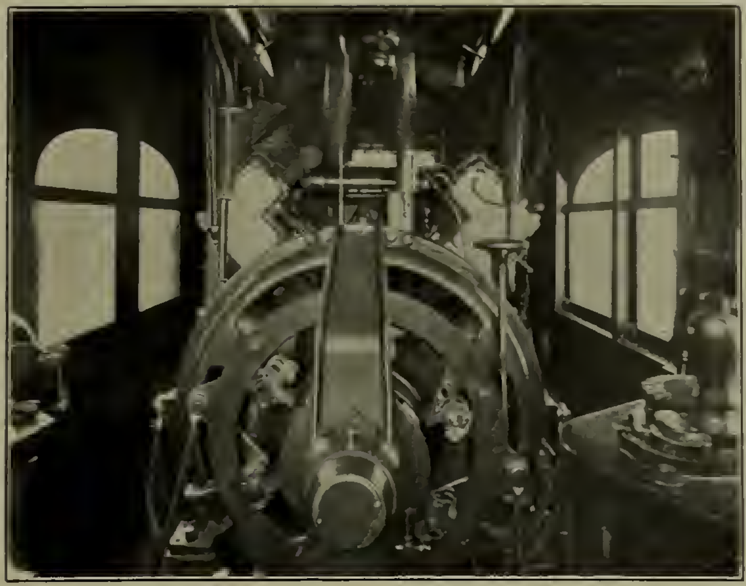
Kerosene, alcohol or crude oil may be used instead of gasoline, by a slight adjustment of the vaporizer. High-tension, or "jump-spark," ignition is used, one coil being provided for each cylinder, and operated by a common interrupter.

A GASOLINE-ELECTRIC CAR, EQUIPPED WITH THE SYSTEM OF THE STRANG ELECTRIC RAILWAY CAR COMPANY, OF NEW YORK. THE CAR WAS BUILT BY THE J. G. BRILL COMPANY, PHILADELPHIA, PA.

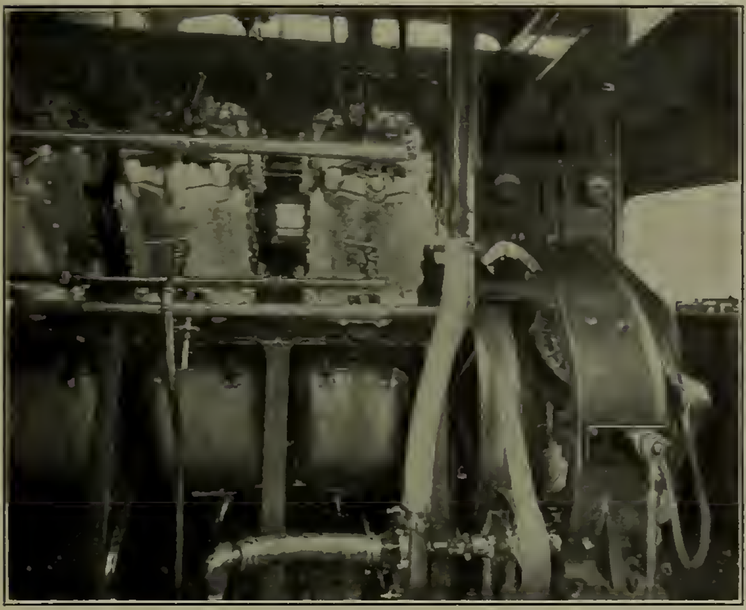


GENERAL PLAN OF THE STRANG SYSTEM

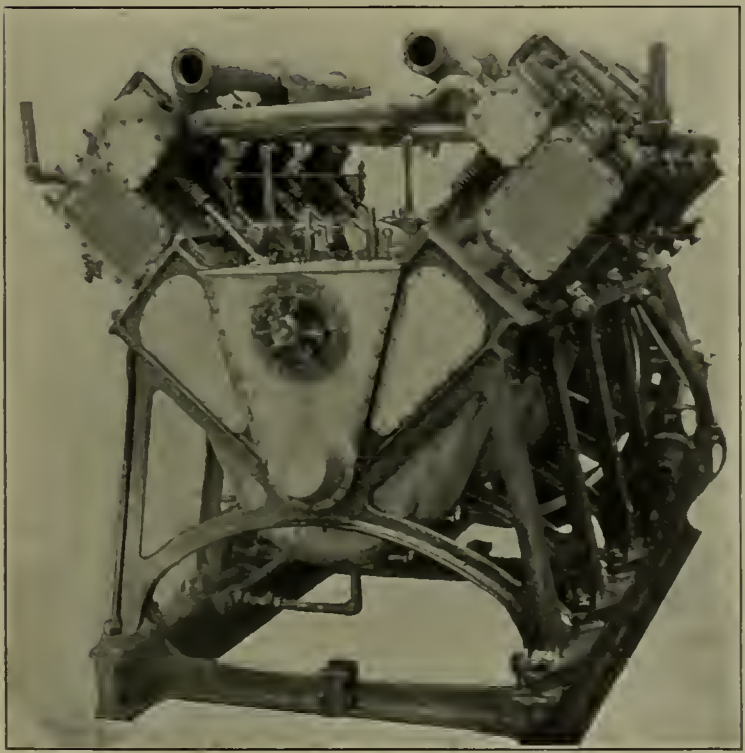
E—Engine
D—Dynamo
B—Battery
C—Controller
M M—Motors
R—Starting Rheostat



THE ENGINE ROOM OF A STRANG ELECTRIC RAILWAY CAR AS SEEN THROUGH THE FRONT WINDOW



A VIEW OF THE ENGINE THROUGH THE SIDE DOOR



REAR VIEW OF THE ENGINE SHOWING COMMUTATOR

The commutator is placed outside the casing at the rear of the engine, and is driven from the end of the cam shaft.

Radiating pipes, for cooling the jacket water, are placed on the roof. In cold weather, the jacket water is used for heating the passenger compartment. Gasoline is pumped from a tank under the floor, to an overflow cup at the side of the vaporizer, the excess being returned to the tank.

The electrical equipment consists of a 50-KW. 250-volt, direct-current generator, direct-coupled to the gasoline engine, two 50-H. P., series-wound motors of the regular street-railway type, two controllers, and a storage battery of 112 cells, having 200 ampere-hours capacity. A cradle under the middle of the car is provided for the battery.

For running on a level track under ordinary conditions, the current goes directly to the motors, but, when coasting down grade, slowing-up, or standing, the surplus current is taken up by the batteries and given out again during acceleration or when climbing steep grades. The battery thus acts as an equalizer, and the engine takes care of the normal load.

The system is in line with power houses where the peak of the load is carried in the same manner. The battery is of comparatively small size, as it is rarely called upon to furnish current for more than a few minutes at a time. Ordinary use improves and is necessary to keep a battery in good condition, and it is entirely practical to build a battery of small capacity with a long life.

As to preventing the battery from being overcharged while running with a light load, it will be remembered that it requires a pressure of $2\frac{1}{2}$ volts to charge a storage battery, while during this charge the pressure falls about two volts. The average voltage supplied to the motors practically corresponds to their rating, and, therefore, with a light load they will run faster in their endeavor to use it up, while with a heavy load the voltage will fall sufficiently to allow the batteries to assist the generator in furnishing the necessary current.

In other words, as the electric transmission is elastic, there is always a tendency to adjust the speed of the car to that which is most suitable and economical for the primary power equipment. Moreover, the engine is provided with automatic governing devices dependent entirely upon the condition of the batteries and the consumption of current. This arrangement has nothing to do with the speed of the engine or the motors, but is simply an additional safeguard against overcharging the batteries, and is entirely automatic and solely for the purpose of economizing fuel and saving the battery when the car is running light or standing still.

The switchboard is placed against the left side of the engine compartment within easy reach of the operator. It includes voltmeter, ammeter, starting rheostat and spark control. The platform at the rear of the car is equipped with a controller and a combination volt and ammeter.

The maximum speed of the car which can be maintained, is 50 miles an hour. The average gasoline consumption is 0.45 gallon per car-mile. One hundred gallons of gasoline are carried, giving a mileage radius of 225 miles.

A New Resistance Box and Wheatstone Bridge

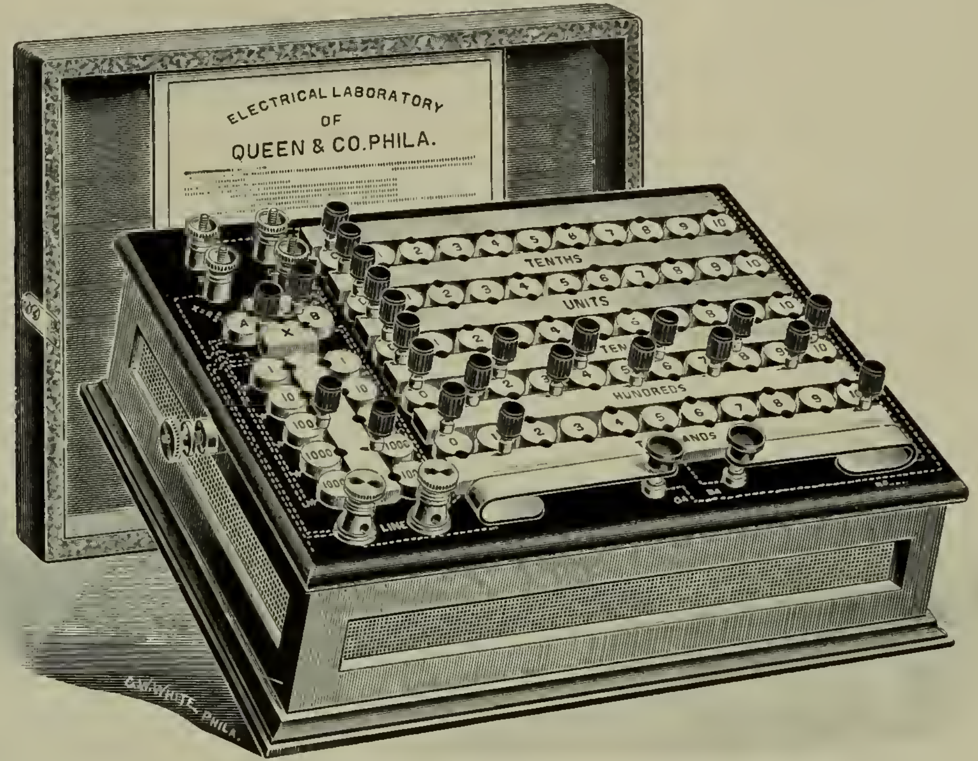
A NEW universal decade box Wheatstone bridge, with several novel and attractive features recently brought out by Queen & Co., of Philadelphia, is shown in an illustration on page 310. It is considerably smaller in size, but in arrangement very similar to the well-known Anthony form.

The rheostat proper consists of fifty coils, ten each of tenths, units, tens, hundreds, and thousands, and so arranged that all the coils in any bank can be connected in series, multiple, or various combinations of the two. This arrangement lends itself particularly well to the thorough and complete interchecking of the coils; for instance, the ten 100-ohm coils can be connected in multiple and compared with each 10-ohm coil, and the latter can in turn be compared with the 10-ohm coils connected in series. This interchecking can also be extended to the other coils in the rheostat.

The bridge consists of a unit, ten, hundred, thousand, and ten-thou-

sand-ohm coil in each arm, which can be reversed by means of a commutator and their equality determined to a nicety.

Battery, galvanometer, and line



A NEW RESISTANCE BOX AND WHEATSTONE BRIDGE, MADE BY QUEEN & COMPANY, PHILADELPHIA, PA.

posts are provided, and in the galvanometer and battery keys, special care has been taken to use a gauge of metal which will not tire the operator and yet allow perfect electrical contact to be made.

The connections are engraved in dotted lines on the hard-rubber top, the double line indicating the heavy interior connections and the single lines showing the galvanometer and battery circuits. The lower edges of the metal blocks and bars facing each other are beveled slightly, and owing to the circular form of metal block, much greater insulating space is secured than with the older form of rectangular block.

The coils are wound with "Manganin" wire, thoroughly shellaced, aged, and baked. The accuracy of adjustment of the bridge coils is 1-50 per cent., that of the thousands, hundreds and tens in the rheostat, 1-25 per cent., the units 1-10 per cent., and the tenths 1-5 per cent. of their stamped values.

The perforated metallic sides allow a free circulation of air, which together with the low temperature coefficient quality of the wire used, makes the box practically independent of temperature.

If requested, a table of readings accurate to 1-50 per cent. will be supplied with each set, showing the actual measured resistance of each coil. Twenty-four plugs and two travelers are supplied. When not in use a polished hardwood mahogany cover, similar to the box itself, fits over the hard-rubber top and plugs, effectually protecting them from dirt and the action of the light.

This set will be found to be of great value in the ordinary laboratory when accurate measurements are necessary, and the expense of one of the large Anthony type bridges would not be justified.

A Mercury-Arc Rectifier in Multiple with a Motor-Generator

A MERCURY-ARC rectifier in multiple with a motor-generator is now in use by the Pacific States Telephone & Telegraph Company, of San Francisco, for the charging of storage batteries.

This company recently purchased a 20-ampere General Electric mercury-arc rectifier outfit and installed it in the Alameda exchange in order to test it in commercial operation. The load on this exchange is so heavy, however, that if the battery were to be charged at only 20 amperes it would be necessary to keep the charging current on for 12 or 15 hours a day. It was, therefore, determined to try to operate the rectifier in multiple with a direct-current generator driven by a single-phase motor, and charge the battery at the normal rate of 40 amperes.

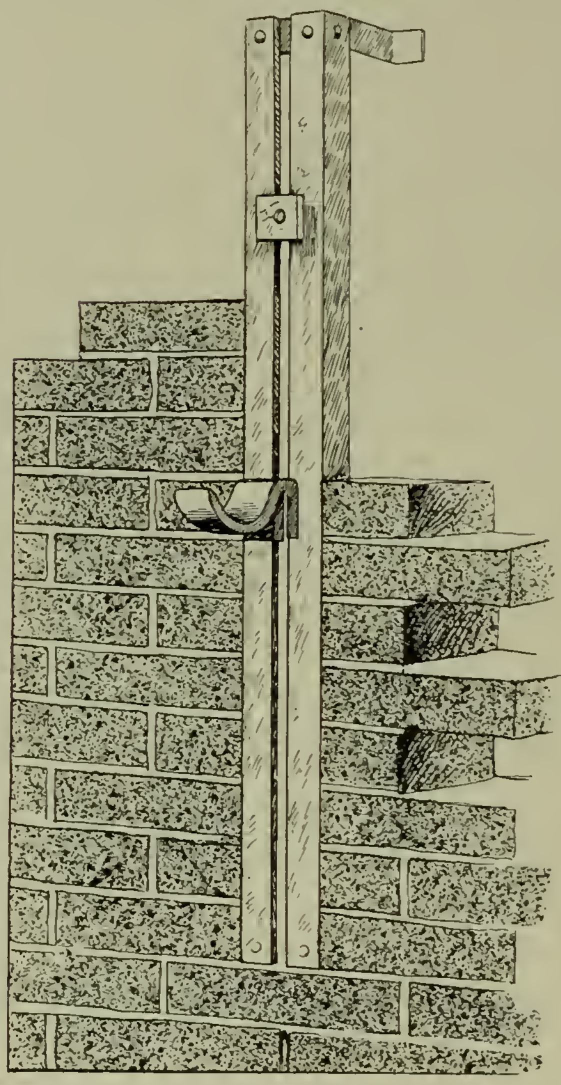
The generator was started up and thrown on the battery and the voltage adjusted to give about 10 amperes charging current. Next the rectifier was started in the usual way, adjusted to charge at about 20 amperes, and thrown into parallel with the generator. The generator voltage was then raised until the current through the battery was 40 amperes, and the charging proceeded.

As the electromotive force of the battery rose and the rectifier current fell off, due to the higher voltage of the generator, the voltage of the rectifier was raised by means of the rheostat at the bottom of the panel. The rectifier voltage could also be varied while the rectifier was operating, by moving the compensating reactance switch, as the voltage of the generator kept the arc going while the switch passed over the dead points.

This scheme of operating the mercury-arc rectifier in parallel with the generator has been in regular operation ever since it was first tried, and it is now possible to charge the battery in three-quarters of the time previously required.

A New Cable Rack

A CABLE rack possessing many novel features has been patented by G. M. Gest, of New York. As may be seen from the annexed illustration, the cable rack, when installed, is flush with the inside wall of the manhole, thus taking



A NEW CABLE RACK PATENTED BY G. M. GEST, NEW YORK

A GASOLINE MOTOR TRUCK BUILT BY THE KNOX AUTOMOBILE COMPANY, SPRINGFIELD, MASS., FOR CARRYING AND LAYING UNDERGROUND CABLES

up no room in the manhole proper.

The inside dimensions of the manholes are small at best. The cable racks heretofore designed have always extended into the manhole, and, when the cable hanger was attached to the cable rack proper, took up from 4 to 6 inches on each side of the manhole, making, in other words, a loss of 8 to 12 inches of the valuable space.

One other special valuable feature is the fact that these hangers can be placed at any point from the top to the bottom of the cable rack,—an entirely new feature, as all other cable racks have the hangers placed at stated points or openings.

A Gasoline Truck for Laying Underground Cables

To carry cables and to aid in placing them underground is the work to which the gasoline motor truck shown in the accompanying illustration is put by the New England Telephone & Telegraph Company, of Boston. Built by the Knox Automobile Company, of Springfield, Mass., it is claimed to be the first machine of its kind put into service.

The chassis is the same as that used for an ordinary 3-ton truck, and is driven by a 20-H. P., horizontal, two-cylinder Knox motor of the air-cooled type. At the rear of the platform is a heavy channel-steel framework on which is mounted a transverse winch shaft with a winding drum at either end. The shaft is driven by chain gearing from the engine shaft, and the motion is controlled by a friction clutch worked by a lever located near the drums.

The platform measures 6 by 12 feet, and is mounted high enough to clear the mechanism of the winch. It is provided with stake sideboards, and is designed to bear heavy loads.

Although the usual method of drawing electric cables through underground conduits has been by hand-driven winches, a few heavy electric trucks equipped with winches driven by small independent motors have been used for this purpose, but in the truck here shown the power is taken from the main driving motor of the truck. The principal advantage of this is that all superfluous machinery is eliminated.

Electric Pumps for Municipal Water Supply

The new pumping station for supplying the city of Schenectady is operated by electric motors, and is capable of pumping 24,000,000 gallons of water per day against a head of 110 pounds. The pumps consist of two 18-inch, two-stage, vertical-shaft Worthington turbines, each consisting of an outer casing, inside of which is a set of fixed diffusion rings and the impeller. Water is drawn through a 42-inch suction pipe from two wells 50 feet in diameter. The vertical shafts of the pumps are direct-coupled to the rotors of two 800-horse-power, 550-volt, three-phase induction motors, operating at 40 cycles per second and a speed of 800 revolutions per minute. The current is supplied by a 10,000-volt transmission line from the Schenectady Illuminating Company, obtaining power from Spiers Falls. As a safeguard against possible stoppage, the lines are also connected with stations of the General Electric Company.

A novelty in the way of invention recently patented is an initiating apparatus to be used in initiating candidates to membership in secret organizations. A casing having the appearance of a book has a portion of the top cover pivoted so that it may be revolved through 180 degrees. On the outer side of this cover is inlaid the emblem of the organization, and on the reverse side is similarly inlaid a device symbolic of the principle or virtue which it is the object and aim of the society to promote, each plate being illuminated by a small electric lamp. In an interior case is a cartridge. When the candidate for initiation places his hand upon the book a button is pushed, the cartridge is fired, and a spring instantaneously carries the section of lid through 180 degrees, thus apparently transforming the illuminated emblem into an illuminated mystic symbol.

Personal

Francis B. Crocker, professor of electrical engineering, Columbia University, New York, and Henry G. Stott, superintendent of motive power of the Interborough Rapid Transit Company, New York, have been invited by President Roosevelt to serve on the newly appointed national advisory board on fuels and structural materials.

M. L. Sperry has been appointed superintendent of the local business of the Taylors Falls power development now under way near Minneapolis. Mr. Sperry succeeds N. E. Seavey, who will undertake special work in connection with the development. Mr. Sperry has been connected with Stone & Webster, of Boston, for several years in the capacity of manager and engineer, having had charge of the Stone & Webster interests at Ponce, Porto Rico, Savannah, Ga., and other points. He is a graduate of the Massachusetts Institute of Technology.

Albert Ladd Colby announces that he has opened an office as consulting and inspecting engineer, and iron and steel metallurgist. His address is 477 Central Park West, New York City.

George W. Fowler has established himself at 136 Liberty street, New York, as consulting electrical engineer and power expert. Mr. Fowler has had an extended experience in the electric power field, having been identified with several important installations of standard and special apparatus for the generation and application of electric power. He was formerly with the C & C Electric Company, but more recently engaged in engineering construction. He will devote his attention especially to the application of electric power to manufacturing and industrial establishments.

F. V. T. Lee has resigned the position of district manager on the Pacific coast for the Stanley-G. I. Electric Manufacturing Company, of Pittsfield, Mass., to become assistant to President John A. Brittin, of the Pacific Gas & Electric Company. H. C. Parker, who has been manager of the San Francisco office, will become acting district manager, and G. I. Kinney, who has been manager of the Seattle office, will be associated with Mr. Parker, with headquarters in San Francisco. Mr. Lee's connections with Stanley interests on the Pacific coast date back to the organization of the firm of John Martin & Co., who were for many years, especially during the time of the pioneer long-distance electric transmission work of that section, the Stanley Company's Pacific coast representatives. Messrs. Parker and Kinney were also associated with the John Martin Company prior to the time of the Stanley Company establishing their own branch offices on the Pacific coast.

Edwin Wilbur Rice, Jr., technical director and third vice-president of the General Electric Company, is a prominent candidate for the presidency of the American Institute of Electrical Engineers. He is a conspicuous example of a man endowed

E. W. RICE, JR.

with the characteristics of a successful modern engineer. After graduation from the Philadelphia Central High School, he continued his investigations in electricity with his former teacher, Professor Elihu Thomson, first in a little shop in Philadelphia, then in New Britain, Conn., and later in Lynn, Mass. With the establishment of the Thomson-Houston factory in the last-named place, his efforts were concentrated on the early problems of the newly found electrical industry. Here his ability was quickly recognized and he was made superintendent. When the Edison and Thomson-Houston Companies were united to form the present General Electric Company, Mr. Rice became prominently identified with the new corporation. In the larger interests of this organization, the grasp of detail and directive ability which had hitherto marked his work were given broader scope, and in 1893 he was appointed chief engineer. Three years later, in addition to his duties as technical director, he was made third vice-president of the company and in that capacity has harmonized the technical and commercial interests of the business. Combined with the characteristics which have been mentioned, Mr. Rice has a splendid intuitive understanding of men. This generalship and directive ability have enabled him to gather about him a most efficient corps of engineers, which makes for the success of the work which he directs.

John F. Wallace, formerly chief engineer of the Panama Canal Commission, will, it is rumored, shortly head a new Westinghouse company, which, it is reported, is now being organized. Before serving in the Canal Commission, Mr. Wallace was chief engineer of the Illinois Central Railroad. His reputation as an engineer has always been of the highest.

Louis J. Magee, resident director in this country for the Allgemeine Elektricitaets Gesellschaft, of Germany, recently returned home to New York from a trip of several weeks in Europe.

C. E. F. Ahlm, consulting and designing engineer, of Cleveland, Ohio, has been retained to prepare plans and specifications for the proposed municipal electric lighting plant for South Brooklyn, Cleveland, Ohio.

Ralph D. Mershon, so well known through his work in high-tension power transmission, has removed his New York office to 60 Wall street.

C. A. Coffin, president of the General Electric Company, who has been touring in the Mediterranean and in Egypt since the first of the year, has just returned home by the White Star liner "Celtic." The trip was very enjoyable and he is in excellent health.

Fred H. Williams, Jr., is now associated with the Hartford Steam Boiler Inspection & Insurance Company, as special agent, with headquarters at Hartford. Mr. Williams is already widely acquainted in his territory, as he is a native of Hartford.

Obituary

G. Martin Brill, president of the J. G. Brill Company, car builders, of Philadelphia, died at his home in Merion, a suburb, on March 31. Mr. Brill was born in Cassel, Germany, in 1846, and when about two years of age was brought to Philadelphia. In 1868 he joined his father, the late J. G. Brill, in organizing the firm of J. G. Brill & Son, which now has one of the largest car manufacturing plants in the world.

Thomas Richard Almond, an inventor and mechanical engineer, died April 1 at his home on Dunwiddie Heights, Yonkers. Sixty-one years ago, he was born in Rocklandshire, England. When 12 years old he won a medal at a London exhibition for a steam engine valve gear. He came to America in 1866, and opened a shop in Fitchburg, Mass. He opened a shop in Brooklyn in 1875. The most important of his inventions, from an electrical point of view, was the flexible conduit for wiring. He also invented the club skate, the Almond quarter-turn countershaft, by which power may be transmitted through a right angle, and the Almond reaction engine. He twice received the John Scott medal for mechanical inventions awarded by the Franklin Institute of Philadelphia. He was a charter member of the American Society of Mechanical Engineers, the American Association for the Advancement of Science, and many local clubs.

John Christian Kafer, lately president of the Engineers' Club of New York, died in Trenton, N. J., on March 30. He was born in Trenton, N. J., in 1842, where his father was a partner of John C. Stevens, at one time president of the United Railroads Company of New Jersey. The outbreak of the Civil War found Mr. Kafer in the prosecution of engineering studies and work, and in 1863 he was appointed third assistant engineer in the navy. The morning of President Lincoln's death, Mr. Kafer sailed for the Mediterranean on the famous old "Kearsarge," whose executive officer was Lieutenant-Commander Geo. Dewey. During the term of Commodore Loring as engineer-in-chief of the navy, Mr. Kafer became his principal assistant and served in a similar capacity under Admiral Melville when the latter became engineer-in-chief. He taught at the Naval Academy from 1868 to 1874 and from 1875 to 1882. He became associated with the Morgan Iron Works, of New York City, serving as vice-president, superintendent, secretary and treasurer. He then became connected with the Quintard Iron Works, and within the last month had organized the

JOHN C. KAFER

consulting firm of Kafer, Mattice & Warren. Mr. Kafer was one of the most active members of the Engineers' Club. He also served as a member of the board of management of the American Society of Mechanical Engineers, of which he had also been vice-president. He was the senior American member of the Institution of Naval Architects of Great Britain, a member of the American Society of Naval Engineers, the Society of Naval Architects and Marine Engineers, and of the Engineers, Army and Navy, and Players clubs in this city. Three years ago it was largely through his instrumentality that the gift of $1,500,000 was secured from Mr. Carnegie for the United Engineering Building and the Engineers Club.

Trade News

The capital of the Standard Roller Bearing Company, of Philadelphia, has been increased from $2,000,000 to $3,500,000. This increase in capital has been required to provide for an enlargement in factory and equipment. A four-story factory 150 by 200 feet will be erected immediately for the manufacture of annular ball bearings, on which this company holds basic patents. During the past year the Standard Roller Bearing Company have equipped with machinery a four-story building, 95 by 200 feet, and have also built and equipped an iron foundry 70 by 150 feet, two stories in height; a hardening and tempering building, 70 by 150 feet, and a crucible-steel casting plant, 60 by 100 feet. With the new building, which will be erected immediately, the company will employ over 1000 hands in the manufacture of steel balls, ball bearings, roller bearings, automobile axles and annular ball bearings.

The Rail Joint Company has closed contracts for the enlargement and new equipment of their works at Troy, N. Y. These improvements will enable them to double their output of previous years. They are now running day and night while the improvements are in progress, to keep pace with the growing demands from steam and electric railroads for the three types of base-supported rail joints known as the "Continuous," "Weber," and "Wolhaupter" types for tee and girder rail sections; also insulating and compromise or step joints to unite different sections of rails, thus maintaining a perfect surface, and doing away entirely with low joints. The general offices of the company are at 29 West Thirty-fourth Street, New York City.

The Automatic Refrigerator Company, of New York, is about to remove its office, shop, and refrigerating show plant to Hartford, Conn., where provision has been made for increased manufacturing facilities.

H. B. Logan has been elected president of Dossert & Co., of New York, manufacturers of solderless connectors for electric wires and cables, vice J. L. Holland, resigned. They have removed to 242-244 West Forty-first street, where they have largely increased facilities for manufacture.

The Oswego Boiler Works, of Oswego, N. Y., have been reorganized under the name of the Oswego Boiler & Engine Company. The new company is under the management of L. L. Bentley, recently mechanical engineer of the Lehigh Valley Railroad.

The Old Colony Street Railway Company, operating roads in the district south of Boston, is about to increase materially its rolling stock. Forty-one additional car equipments have been ordered for this purpose from the General Electric Company, of Schenectady, N. Y. These will consist of 50-H. P. quadruple, direct-current motors, equipped with the Sprague-General Electric multiple-

unit control for operating the cars either singly or in trains. The new cars are to be provided with General Electric straight air-brake apparatus, including air compressors, motorman's valves, governors, brake cylinders, reservoirs, etc. For the present the Old Colony Company will operate cars singly, but with the view of later operating two and three-car trains; these cars are being equipped with multiple-unit control. The Scranton Railway Company, of Scranton, Pa., has also recently ordered for its cars thirty complete straight air-brake equipments. These include air compressors, governors, motorman's valves, brake cylinders, reservoir, etc.

Dodge & Day, engineers, of Philadelphia, have removed their offices to the Drexel Building, in that city.

The Power & Mining Machinery Company, of Milwaukee, Wis., have opened an office in Denver, Col., to better handle their rapidly increasing business from the Rocky Mountain district. The office is in charge of Henry F. Jurs. In order to keep pace with increasing business, the company have awarded contracts for the erection of additions to their shops at Cudahy that will, when completed, more than double the present capacity. These improvements will cost upwards of $300,000, and will include a 200-foot extension to their foundry, the installation of a considerable number of machine tools of special design, and an increase in their shop force of nearly 300 men, which will make the total number employed about 1000.

At the recent annual meeting of the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, the office of general manager, which has been vacant since the death, last June, of Charles H. Wellman, was filled by the election of S. H. Pitkin, whose present title will be first vice-president and general manager. Otherwise no changes were made in the officers of the company.

The Allis-Chalmers Company, of Milwaukee, Wis., report the following recent orders for generating units:—For the Kokomo, Marion & Western Traction Company, Kokomo, Ind., a 1000-KW. turbo-generator; a 30-KW. engine type exciter set; a 35-KW. motor-generator set, switchboards, condensers and piping. For the Astoria, Light, Heat & Power Company, New York City, a 500-H. P., heavy-duty, cross-compound engine, which will be placed in the same station with two Allis-Chalmers horizontal cross-compound engines. For the Georgia Manufacturing & Public Service Company, of Marietta, Ga., one 18 and 36 by 42-inch cross-compound engine. For the Pittsburg Plate Glass Company, at its Crystal City, Mo., plant, an 1800-H. P. gas engine direct-coupled to a 1000-KW. generator. For the Illinois Steel Company, Chicago, two 1000-KW. gas engine generating units. For the Western Canada Cement & Coal Company, Ltd., three 1000-KW. steam-turbine generating units. For Henry Richardi, Bellaire, Mich., the complete electrical equipment for a new water-power plant, consisting of a 375-KW. alternator, exciter, switchboard, transformers, etc.

The Inland Power & Electric Company, of Spokane, Wash., has acquired 30,000 horse-power at Albany Falls, Idaho, and 20,000 horse-power at Hell Gate, in the Columbia River, and an additional power at Metalline Falls, on the Pend d'Oreille River in Stevens County, in this State. The company is incorporated for $1,000,000.

At the annual meeting of the Washington Water Power Company, of Spokane, Wash., held recently, the trustees elected were H. M. Richards, J. P. M. Richards, Thomas G. Thomson, A. B. Campbell, J. D. Sherwood, J. N. Glover, Huber Rasher, D. L. Huntington and W. A. White, Frank Lyman and George W. Southard, of New York. The officers elected were:—H. M. Richards, president; A. B. Campbell, first vice-president; D. L. Huntington, second vice-president and general manager; H. E. Perks, treasurer, and H. L. Bleecker, secretary. The company plans several extensions and new lines during the coming year, and will greatly increase its electrical power developed at Spokane and in Post Falls, Idaho.

During the month of January, 1906, the Westinghouse Machine Company, of East Pittsburg, Pa., entered orders for 22 steam turbines aggregating 56,500 brake horse-power in rated capacity, or an average of over 2500 B. H. P. per turbine. Some of the largest orders were received from the United Electric Light & Power Company, New York, for 15,000 KW.; the New York, New Haven & Hartford Railroad Company, New York, for 11,250 KW.; the Louisville Lighting Company, Louisville, Ky., 3000 KW.; the Oliver Iron & Steel Company, Pittsburg, Pa., 1000 KW.; the West Virginia Pulp & Paper Company, New York, 1200 KW., and the Washington, Alexandria & Mt. Vernon Railway, 1000 KW. The largest machines go to the United Electric Light & Power Company, New York, and will be of 7500 KW., or 11,000 B. H. P. rated capacity. Two of these units have already been sold to the company, which is affiliated with the New York Edison interests. A 3000-KW. turbo-unit goes to Louisville, Ky., and three 4500-B. H. P. units to the New York, New Haven & Hartford Railroad. The West Virginia Pulp & Paper Company already has two 1000-KW. units in service, and the recent order has resulted from the satisfaction given by the first installation.

The Ball Engine Company, of Erie, Pa., reports sales of steam engines to the following:—The Atlanta Steel Hoop Company, Atlanta, Ga., one 150-H. P. single-cylinder engine; the Salt Lake Hardware Company, Salt Lake City, Utah, one 200-H. P. single-cylinder engine; the Union National Bank, Pittsburg, Pa., two 300-H. P. tandem compound engines, one 150-H. P. single-cylinder engine; the Cudahy Packing Company, Philadelphia, Pa., one 70-H. P. single-cylinder engine; the Pennsylvania Steel Company, Steelton, Pa., three 550-H. P. single-cylinder engines; the Massachusetts Cotton Mills, Lowell, Mass., one 500-H. P. single-cylinder engine; the Metropolitan Laundry, San Francisco, Cal., two 300-H. P. tandem compound engines; the Edison Electric Illuminating Company, West Chester, Pa., one 400-H. P. Corliss engine; the Hotel Savoy, Kansas City, Mo., one 175-H. P. tandem compound engine; the First National Bank Building, Chicago, Ill., one 350-H. P. vertical cross-compound engine; the Pittsburg Plate Glass Company, Pittsburg, Pa., two 200-H. P. simple engines; the Kilby Manufacturing Company, Cleveland, Ohio, one 300-H. P. single-cylinder engine, one 200-H. P. single-cylinder engine; the Milwaukee Coke & Gas Company, Milwaukee, Wis., one 550-H. P. single-cylinder engine; the Grand Rapids Railway Company, Grand Rapids, Mich., two 150-H. P. engines; the Wolvin Building, Duluth, Minn., one 150-H. P. single-cylinder engine; the New River & Pocahontas Coal Company, Gentry, W. Va., two 750-H. P. cross-compound engines; Hegeler Brothers, Danville, Ill., one 550-H. P. 4-valve Corliss engine, one 400-H. P. 4-valve Corliss engine.

New Catalogues

Electric rock drills, electric hoists, electric pumps, gasoline engines, water wheels, and electric line and station equipment, built by the H. D. Crippen Manufacturing Company, of New York, are illustrated in an attractive catalogue recently issued. The greater portion of the pamphlet is devoted to the "Box" electric rock drills. These are made in three sizes with motors wound for direct current of 110 and 220 volts. They may be used for sinking, tunneling, drifting and stoping, and for all surface and quarry work.

The Pittsburg Transformer Company, of Pittsburg, Pa., have published a new catalogue illustrating and describing the various types and sizes of transformers built by them. An interesting illustration shows a 60-light Pittsburg transformer which was struck by lightning, bursting off the cover, but which is still operating as well as when first installed.

Panelettes, rosettes, attachment plugs, knife switches, and cut-outs made by the H. T. Paiste Company, of Philadelphia, Pa., according to the National Electrical Code standard, are presented in attractive form in a new circular.

The I. P. Morris Company, of Philadelphia, Pa., have issued a bulletin on the variation in power and efficiency due to changing heads with the number of revolutions constant, as illustrated in the preliminary design of a 13,500-H. P. turbine. The information given should appeal to consulting hydraulic engineers and others making a study of the economic running of water wheels. Curves are also given showing the results of tests made on wheels designed, built, and installed by the company.

The Allis-Chalmers Company, of Milwaukee, Wis., have issued an instruction book on the installation and operation of direct-current motors and generators. The location, alignment, setting of the brush holders, and wiring diagrams are given under the head of installation, and the care of the machine and what to do in case of sparking at brushes are described under the head of operation. Another publication recently issued by the Allis-Chalmers Company is devoted to the electrical equipment of a modern shipyard, that illustrated being the shipbuilding plant of the Fore River Ship & Engine Company, at Quincy, Mass., in which Bullock motors are employed to drive the lathes, plate shears, boring mills, countersinking machine, and the "joggling" machine for up-setting plates.

"Clutchology" is the title of a booklet sent out recently by the Automobile Clutch Company, of Akron, Ohio, giving an illustrated description of the automatic clutch made by them for machine tools, elevators, cranes, countershafts, line-shafts, gas engines, and for manufacturing plants of all descriptions. The clutch consists of a loose member or cup, a tight member which is keyed to the shaft, an operating sleeve, an expansion ring, and an expanding key or lever.

An attractive bulletin recently published by the J. G. Brill Company, of Philadelphia, Pa., gives a number of illustrations of their centrifugal sprinkler cars, showing their construction and operation. One of the cars shown is equipped with a 2480-gallon tank, and will sprinkle 50 feet of roadway on each side of the track. The illustrations show cars with uncovered tanks and others with enclosed tanks.

A series of single sheets issued by the Robins Conveying Belt Company, of New York, illustrate and describe automatic trippers for coal, cement, or refuse distribution; coal conveyors for carrying cargo from shore to vessel; tailings stackers for gold dredges and gold mines; automatic self-reversing trippers; hoisting coal towers operated by steam power, alternating or direct-current motors, and of capacities up to 300 tons per hour; contractors' belt conveyors and bucket elevators; picking-belt conveyors for sorting ore, and belt conveyors for retail coal pockets.

The uses of locomotive cranes are attractively described in a bulletin recently issued by the Browning Engineering Company, of Cleveland, Ohio. The subject is treated with reference to locomotive cranes for railway and power-house service, for use in iron and steel foundries and by gas companies, contractors, shipbuilders, and for handling sand, lumber and stone.

The Stombaugh guy anchor and the Kearney cable clamp are dealt with in a new catalogue sent out by W. N. Matthews & Bros., of St. Louis, Mo. The illustrations are numerous and excellent. A table shows the strains in pounds required to pull out the Stombaugh guy anchor, and under the head of "Recommendations" are given the proper sizes of anchors to use for different cases.

The C. W. Hunt Company, of West New Brighton, New York, illustrate and describe in a new catalogue their coal-handling machinery for power stations, boiler rooms, coal stations, gas companies, coal yards, shipping docks, and manufactories. This machinery includes steeple towers, boom towers, hoisting elevators, mast and gaff, steam shovels, coal crackers, coal tubs, cable railways, trolleys, coaling chutes, screens, wire rope, and wire rope sheaves.

Dodge & Day, of Philadelphia, Pa., have issued a new pamphlet, one of a series covering recent work done by these engineers. It describes the piano factory of Wm. Knabe & Co., at Baltimore, Md., designed by Dodge & Day.

Deep-well pumping engines built by the American Steam Pump Company, of Battle Creek, Mich., are illustrated and described in a catalogue recently issued. These engines are made in 4, 6, 7, 8, 10, 12, 14, and 16-inch sizes. The 10, 12, 14, and 16-inch sizes are furnished with displacement plungers, if required, these plungers being used to assist the action of the pump cylinder in a well where the water is to be delivered to tank elevation, or against considerable pressure.

A recent issue of the bulletin of the Metropolitan Engineering Company, of Brooklyn, N. Y., calls attention to the new electric signs installed by them, and also to the fact that they have become the general agents for Westinghouse electric fans. A number of illustrations are given, showing the location of their latest styles of electric signs.

Lava for mechanical and electrical purposes is the subject of a pamphlet recently issued by the American Lava Company, of Chattanooga, Tenn. The nature and physical properties of this material, as well as its mechanical and electrical properties are well set forth by aid of illustrations and clear descriptive matter. This so-called lava is not, as is frequently supposed, a natural product of volcanic action, but is the mineral known as talc. It possesses extreme hardness, neither swells nor shrinks with changes in atmospheric moisture, and its coefficient of expansion with temperature being negligibly small, it is of especial value in in-

struments requiring a fixed relation of their parts under all conditions. Gas tips and burners are common examples of the practical use of lava.

"Electric Lighting in the Department Store" is the title of a new publication sent out by the Nernst Lamp Company, of Pittsburg, Pa. The quality and quantity of the light, and the best arrangement of the lamps are discussed, and a number of illustrations are given showing the interiors and show windows of a number of large department stores fitted with Nernst lamps. The booklet is in very attractive form, and does not at first glance appear to come under the head of trade publications.

The Elmer P. Morris Company, of New York, in a fifty-one-page catalogue recently issued, illustrate and describe wrought-iron and steel tubular poles and pole brackets for electric railways, electric lighting, telegraph and telephone service. A complete line of overhead line material used in the construction and operation of electric railways is also presented in this catalogue. Much useful information regarding poles will be found condensed in tables for ready reference.

Toll equipment for public and measured telephone service is dealt with in a catalogue recently sent out by the Gray Telephone Pay Station Company, of Hartford, Conn. A number of automatic toll collectors are illustrated and also automatic cabinet sets. Registers for measured service on private or party lines and street corner pay stations are also dealt with.

Loomis-Pettibone gas-generating plants are described by means of diagrams and coloured plates in an attractive pamphlet issued by the Power & Mining Machinery Company, of Milwaukee, Wis. The Loomis-Pettibone system gasifies bituminious coal, wood, charcoal, lignite, etc., and produces a gas that is particularly adapted to the operation of gas engines. The water gas made by this system can be used separately in various feeding work, such as forging, welding, tempering, and like operations.

Rotary converters for railway service are illustrated and described in a bulletin recently sent out by the General Electric Company, of Schenectady, N. Y. The 25-cycle, 600-volt machines listed range in capacity from 200 to 1500 KW., and the 60-cycle, 600-volt machines from 100 to 500 KW. The connections of transformers to rotary converters is shown by diagrams. Other literature sent out deals with isolated plant switchboard panels with circuit-breakers, prepayment attachment for wattmeters, repair parts for railway motors, and speed-regulating rheostats for machine control.

Telephones manufactured by the Dean Electric Company, of Elyria, Ohio, are dealt with in a 32-page pamphlet recently sent out. A very complete line of instruments for a variety of service is illustrated and described. The list follows:—Local battery, compact type, residence, series, bridging, bridging ring-through, central checking, central checking ring-through, non-interfering, non-interfering ring-through, divided circuit, divided circuit ring-through, divided circuit central checking, divided circuit central checking ring-through, harmonic ringing four and eight-party selective signaling, biased ringer four-party selective signaling, and common battery signaling with local battery talking.

Electric Melting Furnaces in the Foundry

IN an address delivered recently before the New England Foundrymen's Association, Dr. Richard Moldenke suggested the use of the electric furnace in foundries for melting stock.

The makers of the latest types of electric furnaces are constantly getting better efficiencies. Now, with a cheap gas, in a gas engine, and for the making of very small castings in small quantity, there is no reason why the small steel, malleable, and even gray casting industry, not to speak of the brass and bronze contingent, should not melt their stock in the electric furnace. The higher price of the work sold will probably stand this. This tendency will bear watching.

He had recently noticed a neat suggestion by Dr. Waldo along this line, where he proposes to make Bessemer steel rings, or suitably shaped small ingots, these to be of the composition of the steel casting. Now, by charging these small ingots into the electric furnace, one obtains a fluid steel of the proper composition to cast. Dr. Moldenke suggested as an improvement that the ingots be pre-heated up to the highest point possible, without injury to the metal, say, just as the ingots for rails or structural steel are treated. This would leave for the more expensive electric current only the finishing heat necessary to melt and superheat to the point right for pouring.

Efficiency Test of a Westinghouse-Parsons Steam Turbine

IN a report recently sent out by the Westinghouse Machine Company, of Pittsburg, Pa., are given the results of a test by Ludwig & Co., engineers, of Atlanta, Ga., of a 500-KW. Westinghouse-Parsons turbine at the company's works. The turbine was designed to develop 750 B. H. P. with a steam pressure of 175 pounds at the turbine throttle, 150 degrees F. superheat, 28 inches of vacuum absolute (reduced to 30 inches of barometer), when running at 3600 revolutions per minute.

With saturated steam, the steam consumption in pounds per brake-horse-power-hour was as follows:—Guaranteed.—Full load, 14.3; three-quarter load, 14.8; half load, 15.7. Actual.—Full load, 13.68; three-quarter load, 14.05; half load, 14.92. With superheated steam.—Guaranteed, 150 degrees superheat, full load, 12.7 pounds. Actual.—105 degrees superheat, full load, 12.22 pounds.

These results were obtained with 25 pounds less steam pressure and 45 degrees lower superheat than were called for in the contract, yet the guarantees were bettered by from 4 to 6 per cent. with saturated steam and 3 per cent. with superheated steam. Applying the proper correction to the superheat test, the steam consumption under 150 degrees superheat would have been 11.7 pounds per brake-horse-power-hour, or nearly 8 per cent. better than the guarantee.

Results Under Electrification in England

THE North Eastern Railway reports that both operating and financial results under electric traction on the suburban lines in the Newcastle district have been entirely favourable. The following comparative figures are given:—

	1903, Steam	1905. Electric
Passengers (half year)	2,844,000	*3 548,000
Earnings (year)	$626,940	$733,860
Running expenses (year)	207,818	†232,206
Running cost per train-mile, cents‡	35	18

By running smaller trains and more of them the company has both pleased the public and made better profit.

* Increase, 25 per cent.
† Double the number of trains.
‡ Including repairs to rolling stock and depreciation.

Book News

Transactions of the International Electrical Congress, St. Louis, 1904

Published under the care of the general secretary and treasurer. Size, 6½ x 9½ inches. In three volumes. Volume I., 879 pages; Volume II., 984 pages; Volume III., 980 pages.

The International Electrical Congress of St. Louis opened on June 1, 1903, when letters of appointment to the committee of organization were issued to about thirty prominent members of the American Institute of Electrical Engineers. This committee held its first meeting at Niagara Falls on July 1, 1903, and a second meeting at the same place on September 18, 1903. At the second meeting the general secretary was instructed to issue invitations to join the Congress to all interested in electricity or its applications. The membership fee was fixed at $5.

The third meeting was held in St. Louis on September 12 to 17, 1904, and papers on the most recent progress in the sciences, applications, and arts of electricity and magnetism were solicited from selected authors in Europe, America, and other parts of the world. These papers, together with the discussions, are incorporated in three volumes. The material is not copyrighted, but publicity is invited.

The general nature of the papers and discussions grouped together in the three volumes may be classified individually as follows:—In Volume I, the mathematical and experimental theory of electricity and magnetism are given, together with general applications. Volume II contains the papers and discussions relating to electrochemistry, electric power transmissions, and to electric light and distribution. Volume III contains the papers and discussions on electric transportation, electric communication, and electrotherapeutics.

Wireless Telegraphy and Telephony

By Domenico Mazzatto. Published by the Macmillan Company, New York. Size 5 x 7½ inches. 416 pages. 253 illustrations. Price, $2.00.

This work has been translated from the original Italian by S. R. Bottone. The author has endeavoured to lay before the reader as simply as possible the principles on which the wireless system of signaling is based. In doing this, he has discussed at length the apparatus which must necessarily be used, and the methods of mounting the apparatus in the sending and receiving stations.

The progress made by the different inventors who have devised special systems of radio-telegraphy is described, and from the first experiments of Marconi at Bologna down to the recent results of trans-Atlantic radiophony, the advances made are traced chronologically.

The twelve chapters in the book are devoted respectively to the following subjects:—General Notions on Wireless Communications; Wireless Telegraphy by Conduction; Wireless Telegraphy by Induction; Radiophonic System; Ultra-Violet and Infra-Red Radiation Systems; Wireless Telegraphy by Electric Waves; Radio-Telegraphic Apparatus; On the Various Systems of Radio-Telegraphy; Syntony and Selected Intercommunications; Practical Experiments and Applications; Wireless Telephony; Various Applications and Conclusions.

Experimental Electrochemistry

By N. Monroe Hopkins, Ph. D. Published by the D. Van Nostrand Company, New York. Size, 6½ x 9 inches. 284 pages. 131 illustrations. Price $3.00.

Electrochemistry is at best a subject for the advanced student, and in order that the experimental work given in the book may be carried out with profit the reader must have beforehand laboratory courses in both chemistry and physics.

The book is arranged so that it may be read through as a history of electrochemistry, both the theory and practice being presented, together with a number of experiments to supply experimental evidence for the theories advanced. In the later and more practical part of the book, the author has introduced exercises in preparing electrolytic compounds and in isolating metals.

Those already well informed on electrochemistry will find considerable new material of interest in this volume, together with suggestions for additional experiments along these new lines. The book seems, therefore, well adapted to the requirements of advanced students and of instructors in electrochemistry.

Real Electric Toy-Making for Boys

By Thomas H. St. John. Size, 5 by 7½ inches. 139 pages. 107 illustrations. Published by the author, in New York. Price $1.00.

A boy will find much to interest and instruct him in this little book. The author has not presupposed that the reader owns a lathe or a small sized machine shop, but has designed things that may be put together with the aid of the tools that nearly every boy is sure to have.

Neither are the toys complicated, but are so simple that the boy of average ability can make them out of ordinary materials. Each design was worked out into practice by the author,—something not always found in boys' books, which sometimes describe things obviously not put into practice.

Electric Fires in Boston

An analysis of the causes of fires in Boston during the past few years, as given in the reports of the Fire Department of that city, brings to light a gratifying improvement in the conditions of electric supply. A common impression that defective electric wires are the cause of many fires, is easily seen to be erroneous in the light of the following figures: During the year ending February 1, 1897, only 67 fires out of 2066 alarms, were attributed by the department of electricity; in the year of 1900-1901, 62 fires out of 2411 were thus charged, and in the year of 1904-1905, 59 fires out of 2651 were supposed to be of electrical origin. The per centage of alarms due to electric fires fell from 3.24 in 1897 to 2.58 in 1901, dropping to 2.22 per cent. in 1905.

These figures show that the habit of charging all mysterious fires to electricity is thoroughly unjust, and, in consideration of the fact that in 1901 but one fire in 31, and in 1905 but one in 45, was sensibly caused by electricity, it is evident that Boston is making an excellent record in the safe use of electricity for power and lighting. In a small town, it is to be anticipated that the percentage of electric fires will not be as high as in a great city, but in any community a record of less than 2.3 per cent. is certainly good cause for congratulation.

The Winter-Eichberg Single-Phase System for a British Railway

The London, Brighton & South Coast Railroad Company, of England, will operate part of its lines by the Winter-Eichberg single-phase alternating-current electric traction system, the British patents for which are controlled by General Electric interests. There will be about 75 miles of track electrified at a cost of about $3,000,000.

All trains entering both the London terminals will be operated by electricity. Each train will consist of three cars, two being motor cars, each with four motors developing 600 H. P. a car.

Technical Education in the Twentieth Century

By JOHN CASSAN WAIT

From the Founder's Day Address, Recently Delivered at the Clarkson Memorial School of Technology

THE foundation of a technical training consists of nature's laws and phenomena, and as nature's laws are fixed and inexorable, a student possessed of a knowledge of what has been, knows what will be, and it is this that forms the ground-work of the twentieth century system of education. But this is not all; it should go further; it should elevate the new generation to a higher plane than mere investigation; it should cultivate powers, a higher ideal and a struggle for genius, the divine, the creative.

An education implies first, a student or scholar to be educated, second, a process or method by which the education is to be acquired, and third, an ulterior purpose or ultimate utilization of the education to some good aim and end.

When the high school or seminary training is finished, several questions present themselves to a young person, among which are three, viz.:—(1) What shall I do or become? (2) Shall I attend school or become an apprentice? (3) Shall I enter the general or technical courses of instruction? The first question must be answered by the tastes, qualifications and opportunities possessed by the person. The second question is usually determined by the pecuniary limitation of the person. The third question depends upon the advantages to be secured or benefits to be derived, and is a subject for discussion under our topic.

It is not a new subject, but there may be some new things in it, in the light of another's experience. I am not an advocate of an extended general course in college as a condition precedent to technical training.

I am no advocate of sixteen years of education before a man or woman becomes self-supporting. He or she is depending too long upon charity or is assuming a debt which may never be repaid. It dwarfs the spirit of independence and self-reliance which the twentieth century needs so much. A young man who accepts his parents' or relatives' support to the age of twenty-four or twenty-six years has forfeited one of the heavenly attributes of human character,—that of manly self-reliance. I would not expect great things of such a young man. If not blessed with influential relatives or friends he must gain his experience and acquire a clientele. His marriage life is postponed and his ideal life shortened by a decade.

In the earlier days of education, theories and laws were assumed by one school, and controverted by others. Fortunately, all this has been changed and modern methods of education are those where observation is cultivated and the reasoning faculties directed to explain the phenomena observed. This is the process of imparting information by directing the student in paths richly bordered with the fruits of wisdom.

The difficulties are removed. The student, though in quest of exercise, has had everything done to lessen the labour. Those obstacles that give to the forest trail its glories, or to the mountain stream its power, have been removed and the Venetian Canal has been substituted.

What is the result? It is that all students have been to Venice; all have observed and been taught the same things. The original trend or natural taste of the child or youth has been limited to the banks of your canal. Your graduates are all alike. Genius has been dwarfed and freedom enslaved.

We need to cultivate heroes whose spirits no conventionalities could restrain and who overcame and turned the tide of the world's ignorance, prejudice and jealousies to the light and the truth. They are originators. They have visions unlike the average man. These limitations in education do not differ solely with the period, but they are greatly affected by the conditions and localities. They are less marked in the smaller and outlying schools than in those of our great communities.

In cities and the great universities located therein, the people forget that the sky overhead is not adamant or lignum-vitae. Their chief sources of knowledge are books. Much profitable learning comes from primitive life and from the discomforts of human existence. A millenium of human comfort and convenience is not healthful to intellectual progress nor to physical development. It is notorious that the strong men and women, those who possess mental and physical superiority, in our schools, in business, and in our industrial and professional occupations, are largely from the country.

In the general courses the studies that you pursue are determined, in the larger universities, by the students' own election. The tendency is toward this plan. By it the student may take his collegiate course and at the same time pursue courses required in the professional classes. This will lead to the three years' collegiate course and is a step in the right direction, if the work of the student be directed or supervised. If he be required to elect his profession or busineess, and to take subjects prescribed or acknowledged to be advantageous in the vocation adopted, then it is, to my mind, most desirable. If the student be permitted to follow his own inclinations, which in four cases out of five will be those avenues of least effort, then the system is detrimental. The student may know less at graduation than at entrance. If he elect the elementary subjects in the various departments, acquire what is popularly known as general culture, and secure the requisite number of points or half courses, he can graduate with a degree, though that may mean positively nothing as an indication of what the student knows.

There is the choice of schools to consider, the large and the small, those in cities and those in country, the general and the technical. But outside of these there are also for consideration the systems that prevail. Some of the schools believe in pursuing several subjects at once, while others pursue one or two subjects only at a time. The various systems have many advocates. Each maintains that its system is the system. There is the choice between the elective and the prescribed courses of study, the experimental and the theoretical systems of teaching sciences.

In my opinion, it is institutions which combine the theoretical and the practical, which limit to a moderate degree the number of courses, which prescribe courses for lower

classmen and leave the election to upper classmen, that truly derive the benefits of both systems.

Cultivate exquisite care and practice heroic effort. As our country grows older and competition becomes greater, the requirements of an education increase. Students who expect and hope to excel in the competition that prevails in our great cities must have something better or something different from that possessed by others.

Refinement should be applied to all that you do and undertake. Your mental training should be refined on the same plan. Put an exquisite finish upon your work. That is what makes the artist; it is what distinguishes the actor and soldier from the business man or labourer, and it is what makes the successful technician or engineer in the present day.

Technical training as offered by our industrial schools tends to develop abnormally particular lines of the intellect and greatly enlarges the scope of one's obversations and power in certain directions. Such a development has been compared to the abnormal development of the five senses. Yet the world has need of such men. He may not be wanted frequently, but occasionally his services are required when they command great prices.

The prevailing idea is that a complete education should be acquired at school. The average graduate from college or technical school hails his degree as the final goal of his educational ambitions. Few study or expect to study after graduation, except perhaps in short crams for a civil service or professional examination.

Such is not the object. The school's aim is to qualify you to study. If you do not continue with your studies you are soon going backward, and at a rate that will appall you when you come into competition with some recent graduate fresh from his studies.

A far-seeing man will, before spending very much time or money for a thing, inquire what specific uses he will make of it, and he will select the object of his purchase with a view to its qualities and its adaptations. A young man who enters college or a technical school should have some idea of what his tastes and capacities are, and should be directed in the lines where his abilities would be best applied and cultivated. I am not one to advise that every man should be a perfect man; neither do I advocate that a whimsical and indolent youth should be permitted to escape essential training in mathematics and sciences by his declaration that he doesn't like them and he does like music, art and other subjects which gain flattery and applause. Yet for one's life work, it is a grave misfortune for one to school himself or herself in a business in which they have not a real liking and to which they cannot bring enthusiasm. Elect something to your liking and something in which there are opportunities and for which there is a demand.

The utilization of technical training in the industrial pursuits and development is everywhere apparent in this country. To no other one element are the country and the people more indebted for their wealth and prosperity. The physical comforts of home, of business and of travel are due to the marvelous provision of the technician.

The economic value of this training is illustrated by the trade, domestic as well as foreign. No country can have claims to world power until it develops the industrial talents of their people and the natural resources of the land. The balance of power remains where the scientific, industrial and mechanical arts are best treated.

Education of this century should not be confined to book learning nor to the study of mathematical and physical laws. Some time should be given to economies and sociology. Methods and means of conserving and protecting what is acquired are quite as important as are the ways, methods and means of acquiring. Close upon the footsteps of progress in its march is trade, with its competition and its protector, economy. The wasteful methods of the pioneer cannot survive the rivalry of commerce. Economy in the production and utilization of materials or power is what effects great savings, and it is the man who can effect great savings who can command a salary commensurate with his savings.

But the twentieth century education should not only cultivate the courage and capacity of a man or woman to cope with nature, but should also give some insight into the laws, institutions and systems of society. It frequently takes some people the best years of their life to become acquainted with themselves and to discover what they really are to the world. Some men take years to overcome the natural diffidence and timidity that possess them, which might be corrected in youth by proper surroundings and by a kindly interest of their teachers.

A discussion of technical education in this century should not omit some reflection upon the social inequalities that are certain to exist. We may look back upon a century mighty in its achievements, gigantic in its forward stride, matchless in its intellectual expansion, industry and invention, in its manifoldness and the vastness of its enterprises, the grandest of all the centuries in history. The heavy burden of labor has been taken from the shoulders of men, and the workman has been made the equal of his neighbor. He has better food, raiment and shelter and better remuneration for his time.

The technical schools should aim to turn out men who can undertake the instruction and improvement of this class of people. Trade schools should be erected and instruction offered in the useful arts. They control the great avenues of commerce, the necessities of life,—food, fuel and raiment. Never was there the necessity for the unity of men and the realization of the dependence of the polite upon the industrial.

The education of the twentieth century will, I predict, enlighten every continent on the globe. What has been begun in the past century will lead to greater and more lasting results in this century. The twentieth century should lead the human race to heights which shall strengthen the faltering steps of art, philosophy and religion.

What the twentieth century demands, is the cultivation of originality and the development of the creative genius of students. Creation should be the highest aim of every student. A small thing created may be truly greater than a large thing borrowed, and the original thought or design of vastly greater import than any imitation. The present century requires the development of geniuses and especially in the technical fields. Old and trodden fields must be departed from, and new, though rough, trails taken. New practices and methods must be devised, and these are more likely to be discovered by departure from than by following in the channels hewn by our predecessors.

The twentieth century education should embody artistic treatment in structural work and in mechanical contrivance,—a relaxation from the intensely practical and economical to a study of what is pleasing and what is beautiful. Some have an idea that there is not much that is beautiful in the mechanical and industrial. Nothing is further from the truth.

It is for the twentieth century education to impart the beautiful and artistic to the useful, to lend inspiration and give expression to the deeper

feelings of industrial life, its burdens, its struggles, its rewards and its glorious victories. The twentieth century should make its technically educated men something more than mechanicians, something more than the mere directors of processes. Men and women should be taught to vary their employment and to seek recreation in the profitable exercise of their intellectual faculties. The spirit of man needs more than gain, more than crowning success of its efforts, more than the applause of fellow men; it needs the hope and cheer of the life everlasting.

The Proper Handling of Consumers' Meters

IN a recent paper before the Northwestern Electrical Association, Geo. H. Barrett recommended that after meters are received from the maker they should be tested with reasonable care, as the connections are sometimes wrongly made, parts are missing, or the meter is so far out of proper adjustment as to preclude the possibility of a careful test having been made at the factory.

When a customer makes a complaint on the amount of his bill, he should be listened to attentively, and unless some reasonable explanation can be given to him by the office man, such, for example, as his bill covering a period of five or six weeks instead of the usual month, the complaint should be turned over to the meter department for adjustment. The man to adjust complaints of this kind must be tactful and polite under all circumstances, and be able to convince the customer that he understands his business, if the customer is open to conviction. The subject should be discussed with the customer openly and frankly. The previous test of his meter, when and where it was made and the result, should be explained and invitation given to assist in a test. He should be interested in the operation of his meter, but in explanations technical terms and phrases should be avoided as far as possible.

Take the cover off the meter and by turning on one, two or any number of lamps and counting the number of revolutions made by the disk in 60 seconds, one can readily tell whether the meter is very far out of the way or not. Having ascertained this, ask the customer to turn on any number of lamps he chooses and tell him from the speed at which the meter is running, the number of lamps turned on. Repeat the test with more or less lamps burning and tell him how many he turned on or off, as the case may be. He will immediately take interest in the test and set about trying to catch you in error. Should it be found that the meter is to some extent fast, make a more careful test, using an indicating wattmeter or any of the various methods used by the craft.

While the customer is interested, instruct him how to make a rough lamp test of his meter, urging him to do so frequently and to read his meter at least once a week. Show him that it is to his interest to become as familiar as possible with his meter. In a little while he will become convinced that the meter can be relied on, and a good friend of the company will have been made out of what might have become a chronic kicker. The effect of educating complaining customers in this way is not only to get the good-will of that customer, but he will relate his experience to other customers and prevent the spread of complaints.

A system of inspection of meter readings should be made by the manager or in the case of the larger plants, by the head of the meter department. For example, a jewel may become cracked or chipped, which would cause a meter to run slow. This will not be detected by an ordinary bill clerk, and meter readings will become less and less until they stop entirely. In too many cases it is not until then that the attention of the meter departments is called to the matter. By having someone with a knowledge of meters and their weaknesses scrutinize the bills, this would be avoided.

Attention was called to the chances for error by confusion of meter constants. For example, a meter having a constant of two might get into the record book as having a constant of one-half and this error carried along for months or even years. This is another argument in favour of having the man in charge of the meter department inspect the readings each month. There is also opportunity for confusion, due to the fact that some meters read in watt-hours and others in kilowatt-hours. Danger of confusion where both classes of dials are used can be avoided by omitting the reading of the first dial altogether.

Resuscitation from Electric Shock

IN a paper read recently before the heads of departments and employees of the Hudson River Electric Power Company, of Albany, N. Y., Dr. L. D. Kathan, of Schenectady, described the methods to be followed in resuscitation from electric shock.

"This is no time for emotion," he said, "but for action; not precipitate, but orderly, according to some well-arranged plan. In these cases, your intelligent and active interference will many times save life. Remove the patient to a table accessible from both sides; lift the feet somewhat; remove the pillow from the head. Put a large electric heating pad over the chest and abdomen; cover the body with warm blankets; begin artificial respiration at once. With the handkerchief, pull the tongue forward so as not to interfere with the free passage of air to and from the lungs; bring the arms well up over the head in this manner till the lungs fill with air, and then slowly turn them to the sides, making firm pressure against the chest, till the air escapes from the lungs.

"Do not repeat this process too rapidly, but do it slowly, not exceeding sixteen or eighteen times a minute, alternately compressing and expanding the lungs in imitation of normal breathing. This should be continued for at least thirty minutes, or until normal breathing is established. I believe the inhalation of oxygen is of distinct value; it can be administered either with normal or artificial respiration.

"It is apparent, that a profound respiratory paralysis exists. We should administer a full dose of strychnine, hypodermically. It is our strongest respiratory stimulant. There is also a paralysis of the vascular and cardiac centers. For this condition, a full dose of adrelin chloride should be given hypodermically. It is our strongest cardio-vascular stimulant. We should repeat both of these doses after fifteen minutes, unless improvement is marked.

"You should not desist in your efforts at resuscitation for at least thirty minutes. There are many cases on record of people having received a lightning stroke, and remaining unconscious for more than an hour, while being resuscitated, so we should not cease our vigilance or abandon hope until it is apparent that all life is extinct."

The power of the Videria and the Rhone Rivers is to be developed for the generation of electricity for use in the Simplon Tunnel. Three-phase, 25-cycle current will be transmitted to the sub-stations at 33,000 volts, and there stepped down to 2300 volts.

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Some German Electrically Operated Cranes

By DR. ALFRED GRADENWITZ

THE advantages of electrically-driven cranes over both steam and hydraulic cranes are too well known to require more than brief mention. The most salient features of electrical operation are the facility of supplying energy by means of a few wires and the comparatively low weight and small dimensions of the motors. As the three main movements of travelling, slewing, and hoisting are mostly performed by three distinct motors, there is no need of any complicated gearing, while the loss of energy due to the transmission of power is greatly reduced.

The particulars given in the following types of cranes constructed by the Vereinigte Maschinenfabrik Augsburg & Maschinenbau Gesells-

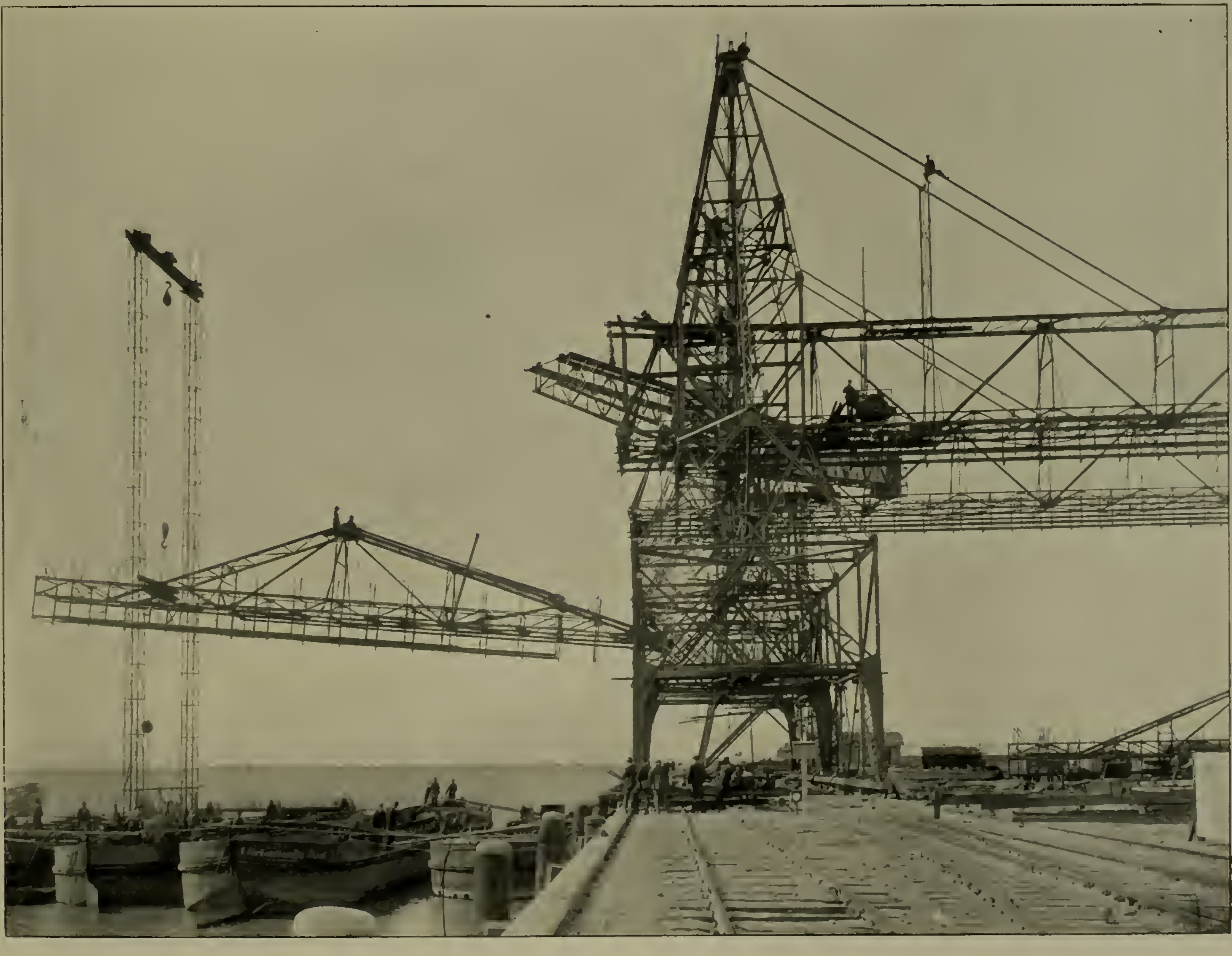
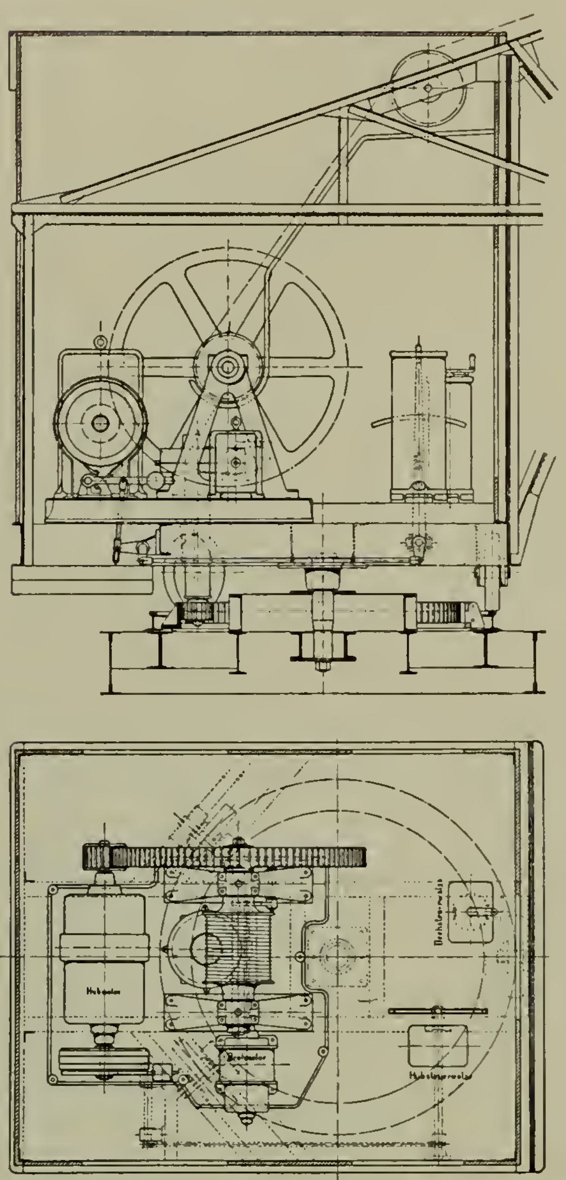


FIG. I.—ELECTRICALLY OPERATED TRANSPORTABLE LOADING BRIDGES IN EMDEN HARBOUR. THESE AND OTHER CRANES SHOWN IN THE FOLLOWING ILLUSTRATIONS WERE BUILT BY THE VEREINIGTE MASCHINENFABRIK AUGSBURG & MASCHINENBAU GESELLSCHAFT, OF NÜRNBERG, GERMANY



FIGS. 2 AND 3.—ELEVATION AND PLAN OF DRIVING GEAR FOR A TURNTABLE CRANE

chaft Nürnberg, will be found instructive, as representing some of the best German practice in this direction.

The scope of one type, called a rotary crane, has been considerably

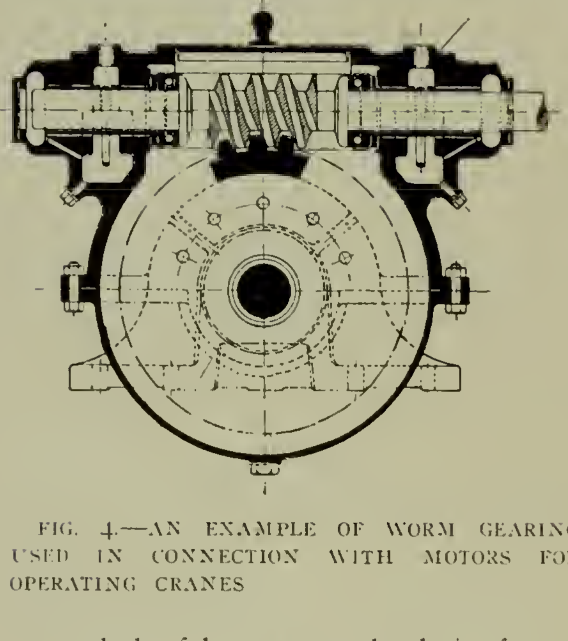


FIG. 4.—AN EXAMPLE OF WORM GEARING USED IN CONNECTION WITH MOTORS FOR OPERATING CRANES

extended of late years, both in foundries and in construction work, as well as in connection with the loading and unloading of vessels. For the latter purpose especially, rapidity of operation is necessary; hence, high working speeds are characteristic of harbour cranes.

Rotary cranes are, as a rule, used in cases where the load is to be moved mainly in a vertical direction, in contradistinction to travelling cranes, which convey the load mainly in a horizontal direction.

In rotary cranes of the turntable type, as shown in Figs. 2 and 3, a platform carries the driving gear and controllers, and is mounted on wheels bearing on a circular rail. This rail, and also the guide for the pivot, are arranged either on a stationary base-plate or on an underframe provided with wheels for running on rails, or else on a trestle either stationary or transportable.

Rotary pillar cranes have an outrigger or jib of framework or sheet metal construction, which is rigidly connected to the rotary pillar, and partly balanced by counterpoises. The rotary pillar is guided underneath by a pivot and at the top by a bolster. The pivot bearing and the bolster bearing are provided with ball or cylindrical bearings for small load capacities and with rollers for larger loads. This type, placed on a rolled iron underframe provided with trucks, becomes a locomotive crane, as shown in Fig. 11. For travelling, locomotive cranes are provided with motors suspended from springs on each axle, in a way similar to tramway motors, with single or double gearing.

In a special form of rotary pillar crane of light construction, shown in Fig. 12, the underframe carries supporting framework for the upper bolster. The rotary pillar is rigidly connected to the partly balanced jib, and the platform for the driving gear and controllers is placed underneath. The rotary pillar transmits the weight of the load through a step-bearing to the underframe. The platform is roofed over by an octagonal glass-walled operator's cabin. The main advantage claimed for this arrangement is lightness of construction combined with great stability.

The driving gear is arranged on the base-plate, the lifting rope being passed through the rotary pillar, or else it is placed on the rotary part of the crane, in case an unlimited capacity of rotation is required.

Rotary tower cranes, examples of which are shown in Figs. 15 and 17, are a special type of rotary pillar crane, and are intended for the loading and unloading of heavy goods as well as for the fitting and repair work of large seagoing steamers. The outer rotary pillar frame is in this case designed as a tower-shaped framework, supporting the roller and step-bearings. On the main girder rails of the jib or outrigger runs a crab analogous to those used in connection with travelling cranes, or else the lifting and crab-travelling gears are readily arranged on the counterarm.

The lifting gear consists mostly of a slow-speed electric motor driving the winding drum through spur gears. A wood-lined, weighted band brake on the motor or gearing shaft is provided to stop and control the lowering of the load. Electrical braking of the lifting motor is sometimes used for lowering the load.

The slewing gear consists of a

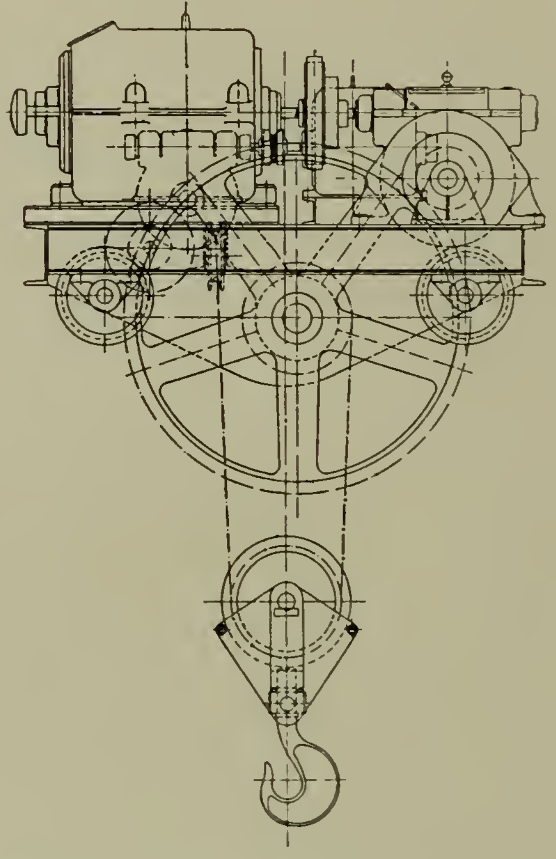


FIG. 5.—A CRAB PROVIDED WITH WIRE ROPE

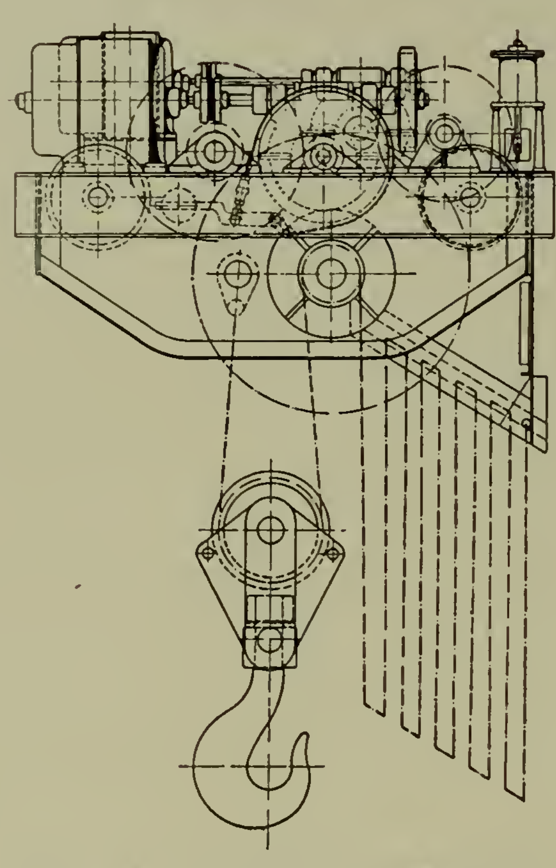


FIG. 6.—A CRAB WITH A CHAIN CABLE FOR HOISTING. THE SLACK OF THE CHAIN IS HELD UP BY THE RACK AS SHOWN

motor, driving, through an elastic leather clutch and horizontal worm-gearing, a pinion gearing with a circular rack. The travelling gear consists of a motor arranged on the underframe and driving the running axle through a leather clutch, and worm and spur gearing. In the case of gantry cranes, chains, or shafts with bevel gears transmit the motion to the running wheels, placed underneath.

The underframes of transportable rotary cranes are made up of rolled iron, and are generally provided with running axles without springs. When intended for harbour and quay traffic, the underframes are designed also in a trunk pyramidal form, or else in the gantry form, so that railway tracks may be kept clear, and the cars allowed to pass under the crane. Gantries consist of a rigidly connected sheet-metal frame and carry the circular rail together with the toothed rim and guiding pivot, the running wheels being fitted underneath. The spur gears are of rawhide and of cast iron, and in some cases of cast steel.

The worm gearings consist of multiple worms, cut from tool-steel, case-hardened, and running with machined phosphor bronze worm-wheels in oil baths. The worm bearings are provided with ring lubrication, and ball-bearings take up the thrust. The whole of the worm-gearing is enclosed so as to protect it against dust and water, while being readily accessible.

As regards the electrical equipment, direct-current series motors of the enclosed type are mostly used. Shunt motors are, however, also used under certain conditions.

Each motor is operated by a special controller in the driver's cabin. The speed is controlled either by means of resistances in the armature circuit or else by weakening the field.

In the case of electrical braking, the motor is connected up as a dynamo, and is short-circuited through variable braking resistances. The mechanical stopping and lowering brake, which is mostly used for the lifting gear, is operated by rods from the driver's stand, and is so connected by means of levers to the controller of the lifting gear that the lifting, stopping, and adjustable lowering of the load are controlled by means of a single lever.

The current is supplied to the rotary portion of the cranes through rings with sliding contacts, and to the underframes of such transportable cranes as are displaced only exceptionally, as are gantry cranes,

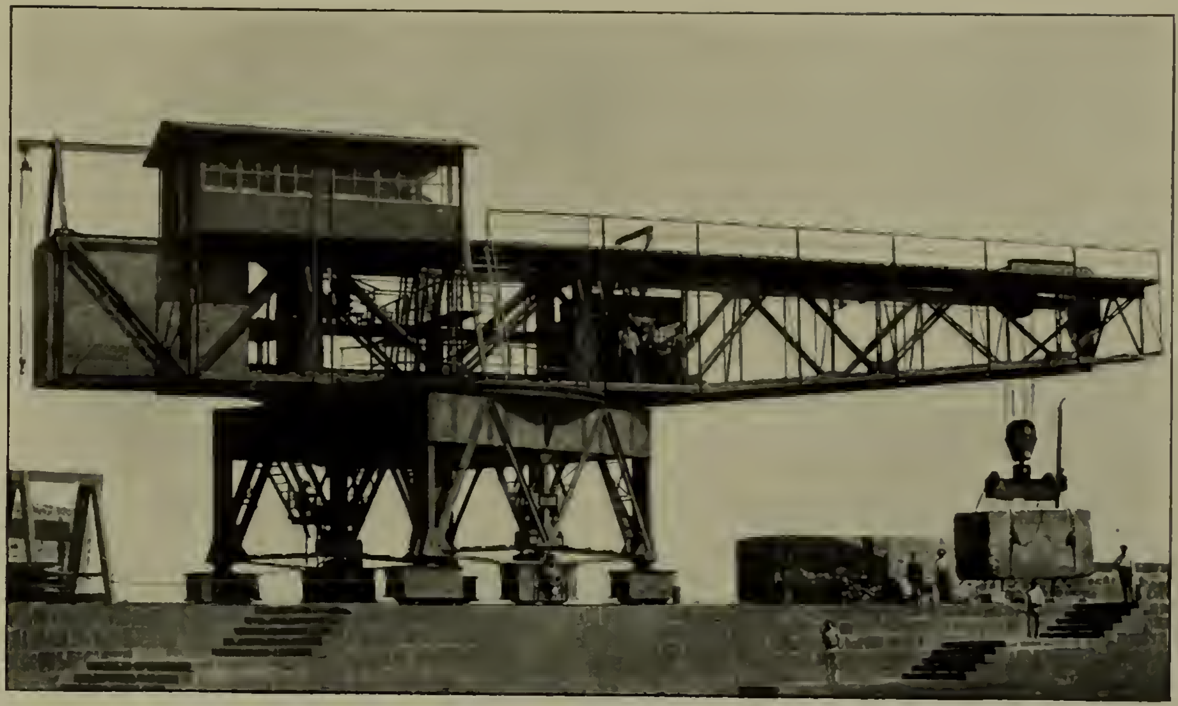


FIG. 7.—AN ELECTRICALLY OPERATED GANTRY CRANE USED IN THE HARBOUR WORK AT SANTA CRUZ DE LA PALMA, CANARY ISLANDS. BUILT BY THE VEREINIGTE MASCHINENFABRIK AUGSBURG & MASCHINENBAU GESELLSCHAFT, OF NÜRNBERG

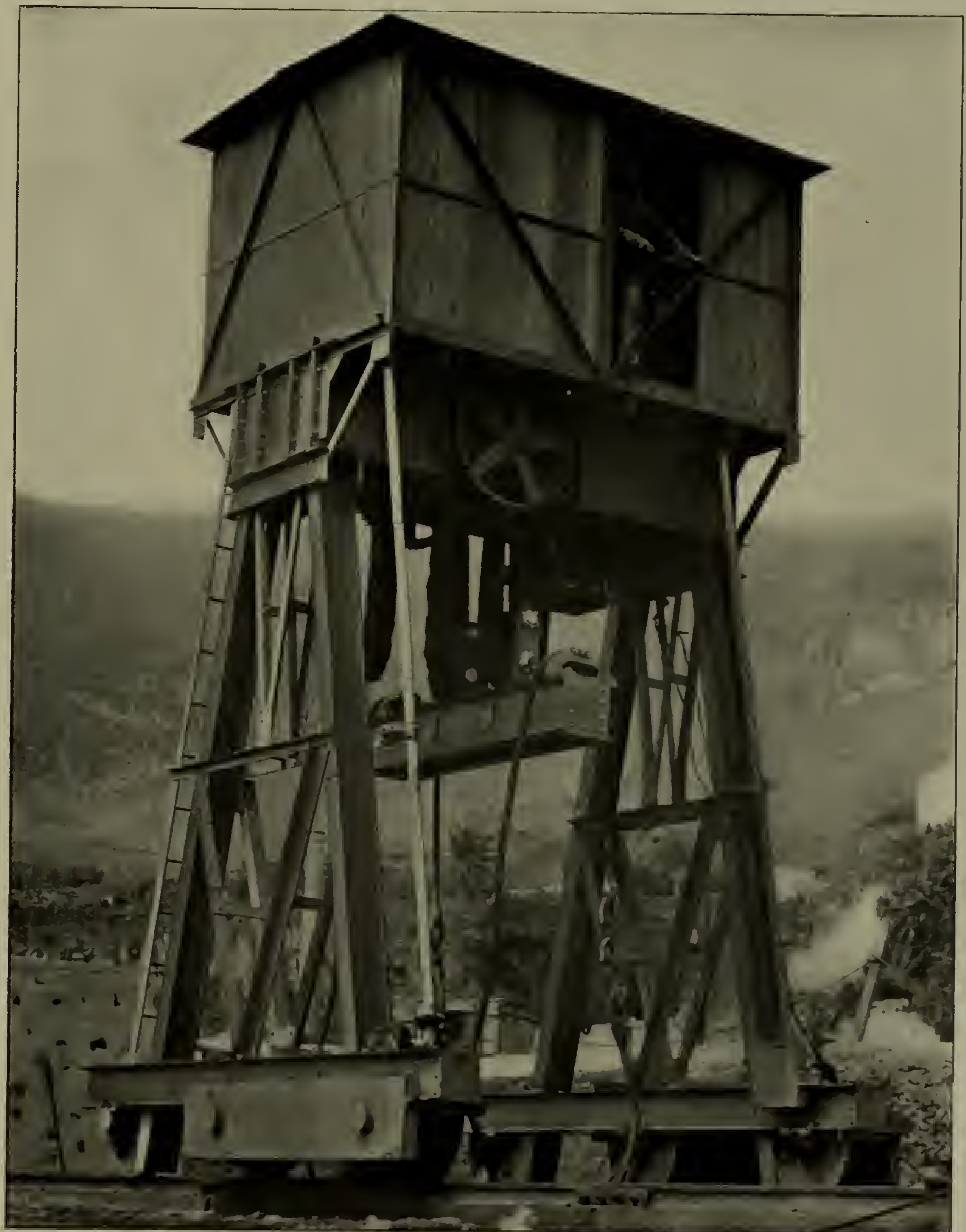


FIG. 8.—ANOTHER CRANE USED IN THE HARBOUR WORK AT SANTA CRUZ DE LA PALMA

FIG. 9.—A 100-TON ROTARY-TOWER CRANE AT DUBLIN, IRELAND

by flexible cables and water-tight contact boxes. In case the crane is displaced frequently (as are locomotive cranes), the current is mostly

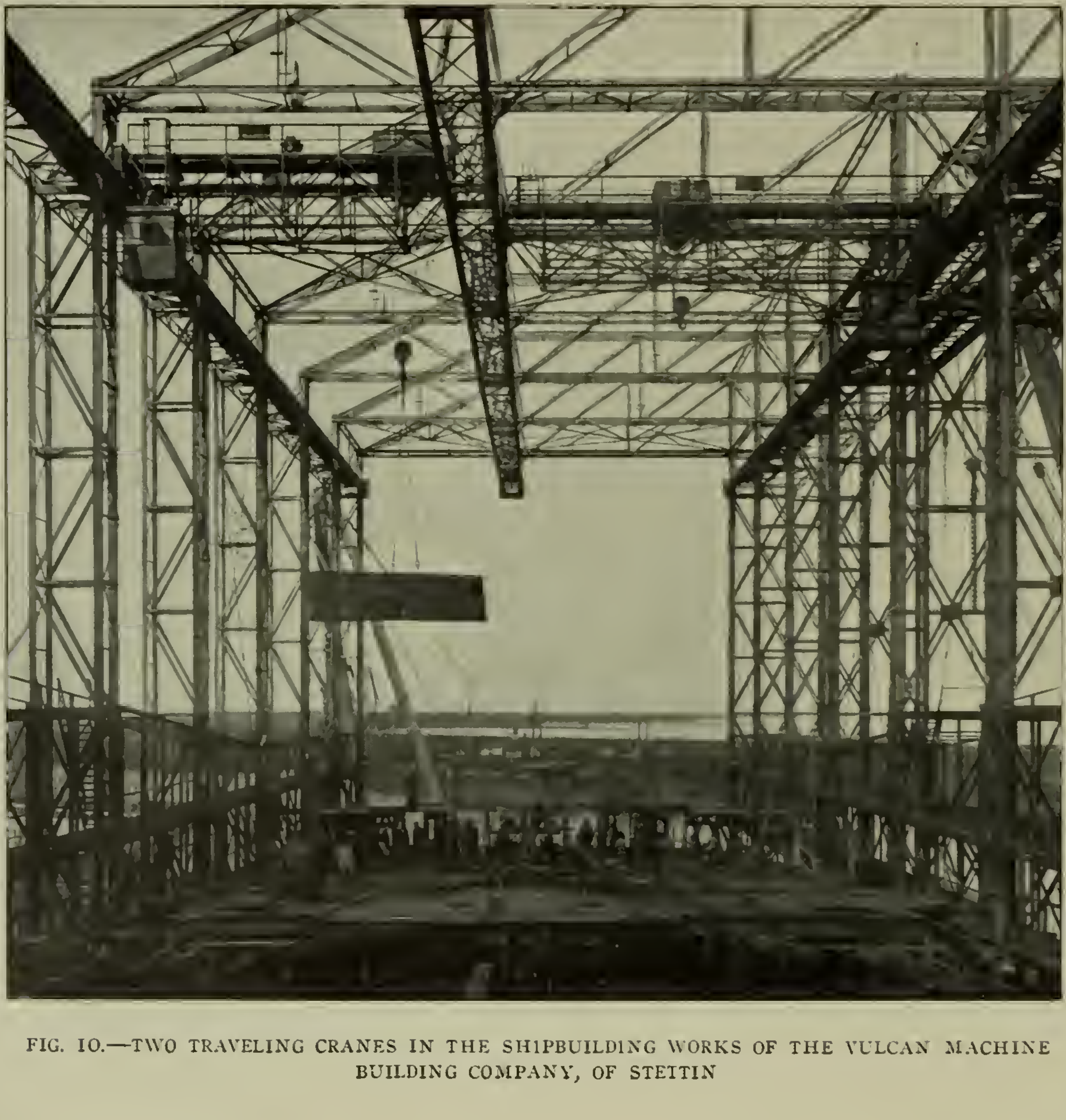


FIG. 10.—TWO TRAVELING CRANES IN THE SHIPBUILDING WORKS OF THE VULCAN MACHINE BUILDING COMPANY, OF STETTIN

supplied by means of sliding contacts or collector rollers in connection with an overhead or underground circuit.

All the controlling levers are arranged at the driver's stand on the rotary part in such a way as to be readily handled and to enable the driver permanently to inspect the working field. The equipment is completed by any necessary switches and measuring instruments on a switchboard.

Transportable rotary cranes are fitted with stopping devices to prevent any involuntary displacement in the case of storms, while locomotive cranes are safeguarded by means of special rail-clamps or movable props against the risk of tilting transversely to the direction of the rails. All the parts of the driving gear are readily accessible.

We shall now consider some of the special installations of the company which are at present in operation. In the extensive harbour work being carried out at Santa Cruz de la Palma, Canary Islands, it was necessary to handle artificial stone blocks up to 50 tons weight. These, having been lifted on trucks by means of the transportable trestle crane shown in Fig. 8, would be hauled by electric locomotives to the gantry crane, shown in Fig. 7, in order to be conveyed and placed in position.

A special feature of the crane is its lightness of construction. The main girder is seen to rest on a roller rim supported by a transportable gantry. The roller rim has a mean diameter of about 25½ feet, and consists of two U-shaped iron rings connected with the bottom of the U adjacent. Between these about 24 rollers are placed around the circumference. The inner ring is connected by radial spokes to a centering piece guided on a trunnion, which is joined rigidly to the gantry.

The crane is transported by means of special trucks arranged between the four wheel-jacks and connected to the angle posts of the gantry by means of cross-braced ties. The four wheels on each truck are mounted in pairs, and are driven by means of spur and bevel gearing from vertical shafts which are located on the framework girders of the gantry.

In order to insure the necessary adhesion, each of the trucks is pressed against the rails by two buffer springs fitted into the framework girders. The main driving gear is located on the platform of the gantry, and consists of an enclosed series motor of 54 H. P., working by means of an electric

leather clutch on worm-gearing, thence to both sides on spur and bevel gears, and thence to the vertical shafts mentioned.

The slewing gear is between the main girders and is driven by a 15-H. P. series motor through worm, spur, and bevel gearing. The lifting gear is operated by a 54-H. P. motor with a leather clutch and the necessary spur gears. The crab is operated by means of two closed chain systems driven by a 30-H. P. motor. Direct current at 370 volts pressure is supplied through cables to operate the entire plant.

The 100-ton rotary tower crane shown in Fig. 9 was constructed for the port of Dublin, Ireland. The rotary part of the crane consists of the vertical crane post and the long arm or jib, and the shorter arm, or counterpoise. The post has a bearing at the bottom, while the upper part is provided with rollers bearing on a bolster.

The outside lattice-braced structure is connected to the foundation, which consists of iron framework reinforced with concrete. The two main girders of the jib are connected together throughout their length by horizontal cross-bracing. The girders are of light construction, and have wide meshes. At the level of the crab runway a running scaffold has been provided on each side of the jib, insuring easy access to the crab.

The lifting and crab-travelling gears are located in the house on the shorter arm of the jib. The motor of the lifting gear drives two drums through spur gearing, and two independently acting brakes have been provided, each of which is able to hold the load in any position. One of these brakes is actuated by an electromagnet, the other being an automatic lamellar brake of patented construction.

Chains running from a motor-driven chain wheel to the crab are used to operate the latter. On the crab itself has been arranged a smaller self-contained gear of 20,000 kg. (22 tons) capacity, the motor of which drives a rope drum through spur gearing. Two brakes analogous to these of the larger lifting gear are provided.

The slewing gear is fitted in the crane post at the level of the bolster. Through worm and spur gearing the motor drives a pinion engaging with the toothed rim fixed to the trestle. An electrically-operated brake enables the jib to be accurately adjusted. The revolution of the jib is unlimited in either direction.

The driver's stand is located between the main girders of the outrigger close to the axis of rotation, and contains, in addition to the controllers, the switchboard apparatus and measuring instruments for power and light. The driver has a very good view of the load and its immediate surroundings with any position of the hook. Direct current at 500 volts is supplied to the crane from sliding ring contacts at the foot.

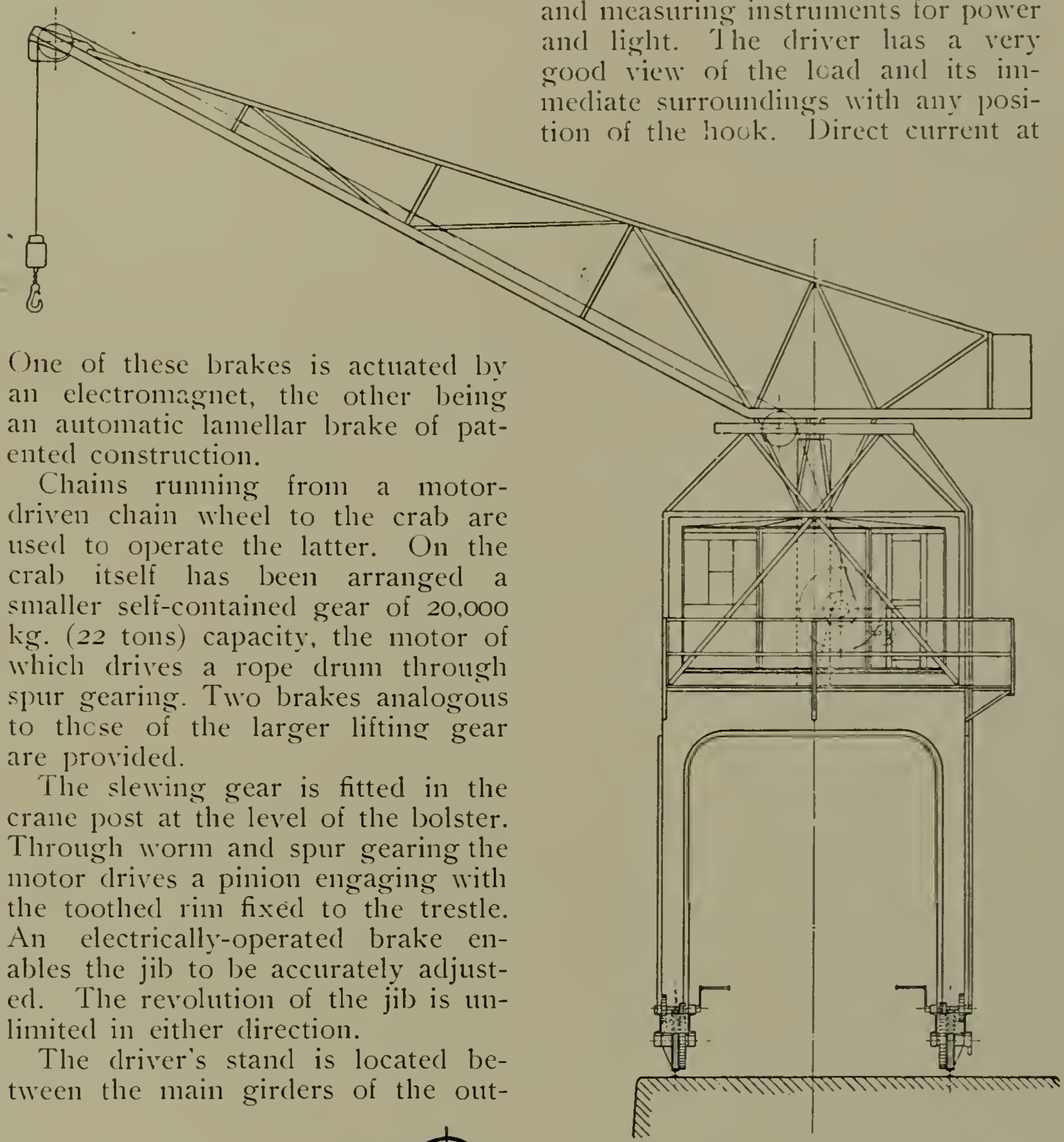


FIG. 12.—A LIGHT ROTARY PILLAR CRANE

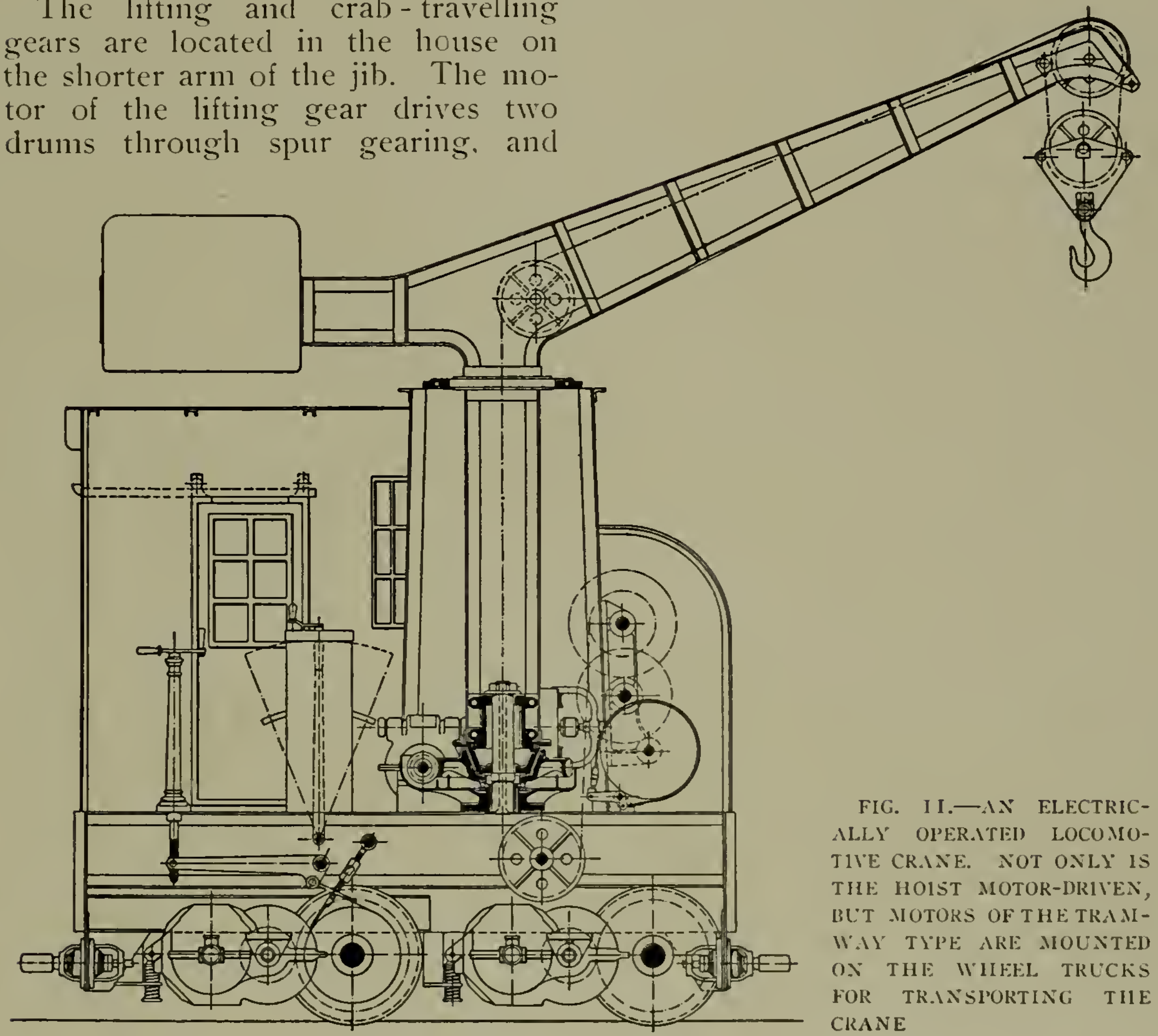


FIG. 11.—AN ELECTRICALLY OPERATED LOCOMOTIVE CRANE. NOT ONLY IS THE HOIST MOTOR-DRIVEN, BUT MOTORS OF THE TRAMWAY TYPE ARE MOUNTED ON THE WHEEL TRUCKS FOR TRANSPORTING THE CRANE

The maximum jib for 20,000 kg. (22 tons) is 80 feet; that for 150,000 kg. (165 tons) is 75 feet. The working speeds are:—Lifting 20,000 kg. (22 tons), 20 feet per minute; lifting 50,000 kg. (55 tons), 10 feet per minute; lifting 100,000 kg. (110 tons), 5 feet per minute; crab travelling, 28 feet per minute. The duration of a complete revolution is 8 minutes.

Five cranes similar to that just described are in operation at the harbours of Hamburg and Emden.

Figs. 15 and 17 show two electrically-operated cranes built for the Imperial Ship Works, at Wilhelmshaven. These cranes, which have been in operation since the beginning of last year, have been found to be extremely economical and relatively inexpensive.

The gantry-shaped underframe travels by means of four steel wheels on a track of 4 meters gauge. The

FIG. 13.—AT THE HARBOUR OF OFFENBACH, THREE TRANSPORTABLE LOADING BRIDGES AND A TRANSPORTABLE GANTRY CRANE ARE USED FOR COAL HANDLING

crane-travelling motor is located on what may be called the first floor of the underframe, and drives the two running wheels through worm, spur, and bevel gears.

The jib is designed to work at two different radii, that for loads up to 3000 kg. (6613 pounds) being 52.4 feet, and that for greater loads up to 6500 kg. (14,330 pounds) being 24.2 feet. For the longer radius, the wire rope runs over the sheave at the end of the jib, as shown in Fig. 15. For the shorter radius, the ball weight at the end of the wire rope is drawn up to the sheave, and, as shown in Fig. 15, the sheave held at the shorter radius is released. When it is desired to use the longer radius, the free sheave is drawn up and secured. All this is done from the operator's stand by a switching device which releases or makes fast the free sheave as desired.

The lifting motor drives the winding drum through the usual spur gearing. A lock brake of special design is provided to stop and lower the load. For slewing, a motor drives a steel worm and phosphor bronze worm-wheel, which, in turn, drives a pinion engaging a tooth rim on the upper platform of the underframe.

A brake is provided to keep the jib in position against the action of the wind, and the jib can also be coupled rigidly to the underframe. A jaw brake is provided as a safeguard against any involuntary travelling of the crane.

Running for about 500 feet along

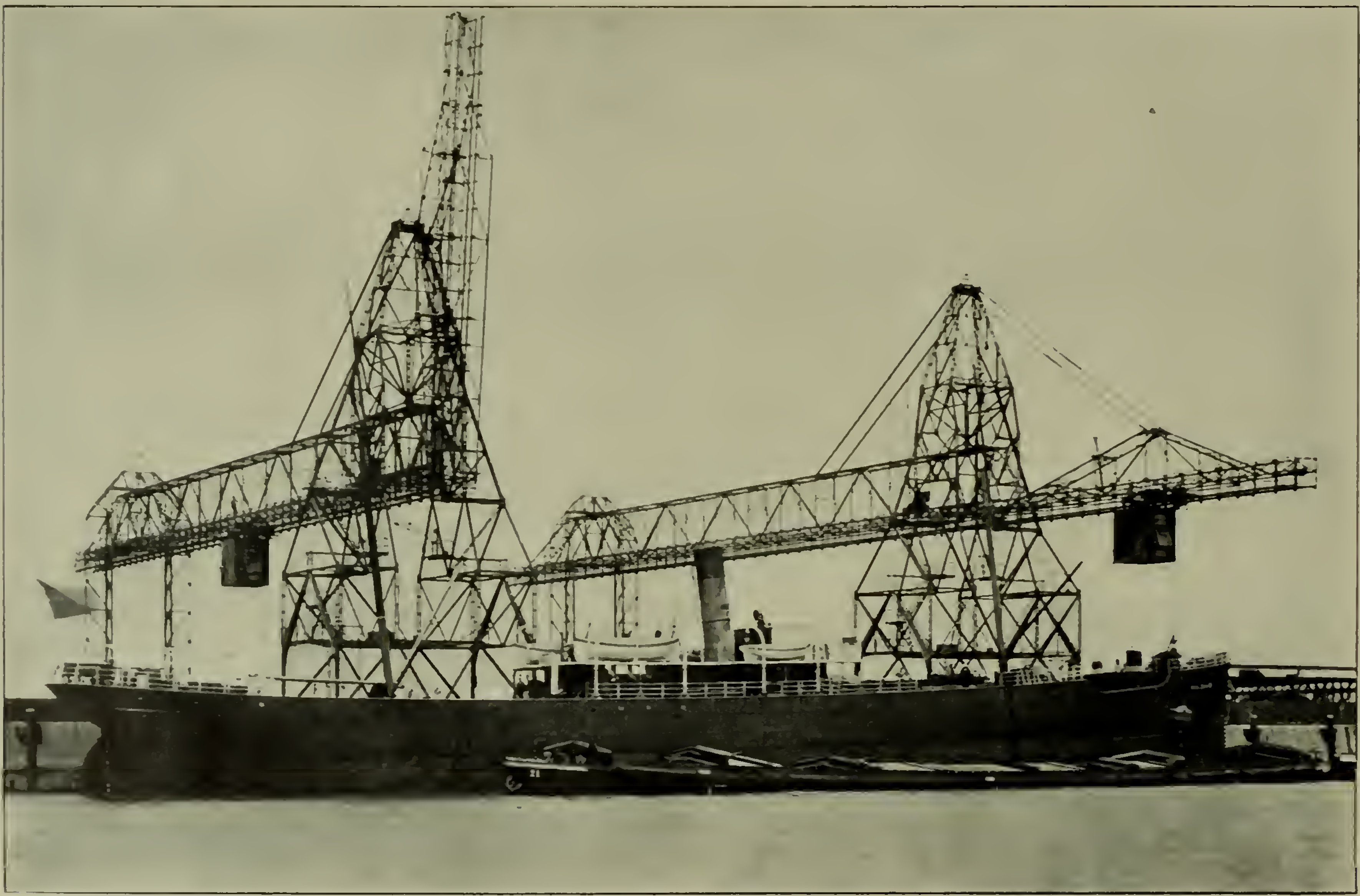


FIG. 14.—ANOTHER VIEW OF THE TWO ELECTRICALLY OPERATED TRANSPORTABLE LOADING BRIDGES AT EMDEN HARBOUR, GERMANY

the runway, the feeders supplying the current are placed on poles of the form shown in Fig. 15. The feeders are tapped and the current is led through the bottom of the pillar to the sliding ring contacts and thence to the switchboard in the operator's house. The speeds of the several operations are as follows:—Lifting, 6 tons, 50 feet a minute; 3 tons, 105 feet a minute. Slewing, 295 feet a minute. Travelling, 100 feet a minute. The lifting height of the cranes is 72 feet for the long, and 65½ feet for the short, jib.

The two travelling cranes shown in Fig. 10 were installed in the building slips of the Vulcan Machine Building Company, of Stettin. The capacity of each of these is 8000 kg. (13 tons).

Figs. 1 and 14 show two electrically-operated transportable loading bridges in Emden harbour. The jib projecting out over the water is about 90 feet long, and at the other end of the bridge structure the crab runway extends outward about 50 feet.

The jib is raised and lowered by two wire ropes running over sheaves at the top of the tower to a winch on the bridge. The two terminal positions are indicated by a gauge and by electric bell signals. For the uppermost portion, an automatic bolting device holds the jib.

From the driver's cabin, which is a part of the crab, the operations of lifting and travelling are controlled. A depth gauge is provided to show the position of the load.

All the starting apparatus has been located in the spacious driver's cabin, which is protected against rain and wind. The various indices are readily inspected, so that the driver, without leaving the cabin, may control the operations of lifting, lowering, seizing and discharging the load, crab travelling, lifting and lowering the jib, travelling of the various supports and the whole bridge.

Direct current of 440-500 volts is supplied to the bridge through a movable cable 150 feet in length, which is wound and unwound automatically by a special device during the displacing of the bridge. A bridge is accordingly enabled to move about 260 feet without any necessity for the cable being switched. On the track, 590 feet in length, there have, therefore, been distributed only four cable contact boxes.

The working speeds are as follows:—Lifting the load, 4 feet a second; lowering the load, 6 feet a second; crab-travelling, from 10 to 12 feet a second; bridge travelling, from 1 foot to 16 inches a second. The lifting of the jib from the lowermost to the uppermost position takes about 4 minutes, and the reverse operation about 3 minutes. The capacity of each bridge varies from 60 to 90 tons an hour, according to the kind of goods handled, the number of workmen in the hold, and other conditions.

Figs. 13 and 16 show the coal-handling equipment at the harbour of Offenbach. The equipment includes six capstans, three transportable loading bridges, shown in Fig. 13, one transportable gantry rotary crane, also shown in Fig. 13, and in more detail in Fig. 16. All are electrically operated by direct current at 580 volts.

The loading bridges serve mainly to convey coal from the vessels to the storage yards or into railway cars. A rotary crane of 4 tons capacity and 32-foot radius, travels on the upper chords of the bridge girders. The advantage of this design as against that of travellers is that the bridge need not be shifted so frequently, the rotary crane controlling a large field of action, while dispensing with the jib otherwise

FIG. 15.—A ROTARY TOWER CRANE AT THE IMPERIAL SHIP WORKS, WILHELMSHAVEN. CURRENT IS SUPPLIED TO THE CRANE BY THE FEED WIRES SHOWN AT THE LEFT, EXTENDING ALONG THE RUNWAY AND SUPPORTED ON POLES

FIG. 16.—A TRANSPORTABLE GANTRY CRANE USED FOR HANDLING COAL AT OFFENBACH

used in an arrangement susceptible of being raised and lowered so as to be out of the way of navigation. The total length of the bridge, as well as the span and tracks of the bridge runway, are made shorter.

FIG. 17.—TWO ROTARY TOWER CRANES AT THE IMPERIAL SHIP WORKS AT WILHELMSHAVEN

Of the two supports, that at the shore end is provided with eight cast steel running wheels, and the other end with four. As the bridge has to traverse a curve, the girder is joined at the water end to make this possible. The travelling is done by means of a motor placed on the lower chords of the bridge.

The rotary crane part of the bridge is on a four-wheeled truck, which runs on the upper chords. The lifting and slewing mechanisms are placed in the cabin, and are operated by separate motors.

The gantry rotary crane is shown in Fig. 17. It has the same general features as the rotary bridge cranes, with a radius of 41 feet and a gantry span of 30 feet.

Gift of the International Electrical Congress, at St. Louis, to the American Institute of Electrical Engineers

A GIFT of $2,052.06, the balance in the hands of the treasurer of the International Electrical Congress at St. Louis, in 1904, has been presented to the American Institute of Electrical Engineers as a fund, the income from which is to be expended in the purchase of international electrical literature for its library.

In a letter to the American Institute of Electrical Engineers, telling of the gift, Elihu Thomson, president of the congress, said that since the American Institute of Electrical Engineers was so closely associated with the International St. Louis Congress in formation, membership, attendance, papers, and success, it is hoped that the acceptance of the residual fund may constitute a suitable permanent memorial of the International Electrical Congress of St. Louis, and may also serve as an indication of the perpetuation of that friendly feeling between international electrical workers that the congress has evinced.

At the last meeting of the board of directors of the American Institute of Electrical Engineers, the gift of the congress was formally accepted, and resolutions adopted to the effect that the fund shall be known as the "International Electrical Congress of St. Louis (1904) Library Fund," and that the annual income shall be expended for the purchase of foreign or non-American electrical literature for the Institute library. The fund, which now amounts to $2,067.06, has been deposited in a trust company.

A single-phase traction system is to be constructed between Locarno and Bignasco, in Switzerland, a distance of 22 miles.

The Regulation of High-Pressure Water-Wheels for Power Transmission Plants

By GEO. J. HENRY, JR.

A Paper Read at the Recent Chattanooga Meeting of the American Society of Mechanical Engineers

FIG. I.—A PELTON WATER-WHEEL IN OPERATION, SHOWING THE JET OF WATER ENTERING THE BUCKETS

WHEN the modern engineer is presented with a problem of safely, economically, and properly governing a power-transmission plant, there are a number of points to receive his exhaustive consideration, aside from the construction of the governor itself.

A modern high-pressure water plant is usually exposed to the danger of a break in the pressure pipe. Such a pressure pipe frequently carries a very large volume of water at anywhere from 200 to 1000 pounds per square inch pressure, and a break in this line in many instances would mean the complete wrecking of the power house. It is, therefore, extremely necessary that the security of this pipe line be guarded in every way; and the old method of regulating turbine wheels by throttling the water is one that should not be adopted without installing suitable protecting devices, and even then, only when it is the only available method.

Of course, in many instances, particularly where a large storage reservoir is available at the inlet of the pipe or at the outlet of the flume, or where the peak load is likely to exceed the normal capacity of the flume (which may be a long one and very expensive), or where it will exceed the normal flow of the stream, it becomes advisable to save all the water possible; and this can only be done by proportioning the water flow to the station load requirements.

Some form of regulating nozzle is, of course, the best way of accomplishing this result, but it does not by any means follow that the regulation of the speed should be coincident with the regulation of the water flow, as will be pointed out later. It is very necessary, in modern power-transmission plants, to maintain the speed within very close limits, and $1\frac{1}{2}$ to $2\frac{1}{2}$ per cent. is readily obtainable with well-designed and constructed apparatus.

It is not customary to attempt to maintain voltages at the end of a transmission line by varying the speed, and, therefore, the voltage at the generator, but modern practice invariably requires the maintenance of a constant speed and voltage. Fluctuations in voltage are then taken care of by varying the generator field or by accessory apparatus.

In many cases it is not permissible to vary the flow of water in the pipe line, the requirements of the irrigation district below the plant frequently being such (and the courts have sustained this) that the full flow of the stream must be permitted to pass through the plant at all times. It, therefore, becomes impossible to regulate the speed of a plant of this kind by varying the water flow, unless an accessory spill-way or pipe-line feeds into the same water discharge channel that water which overflows the pipe inlet.

It is obvious that if the governor which is to be used to move the gates, deflecting nozzles, or other means of regulation, is not provided with a "relay" and a "relay returning device," the speed is very apt to "hunt," causing dangerous fluctuation in the entire system, if not absolutely preventing successful operation. It is also obvious that the rapidity of the governor operation will determine for any plant with a given amount of stored energy in the rotating parts, the variation in speed which occurs before the governor properly checks and corrects the rise or fall in the speed.

On the other hand, every mechanical governor requires a certain change in its speed before it tends to correct the variations. This is due to the lap of the valves, the friction of the parts, etc. Again, in a plant having a large amount of stored energy, a given load fluctuation will produce a slower speed fluctuation. Hence, the governor

will get into operation more slowly, and although oscillation or hunting is still likely to occur, its periodicity will be longer.

On the whole, it may be stated that while the greatest permissible rapidity of governor control is high-

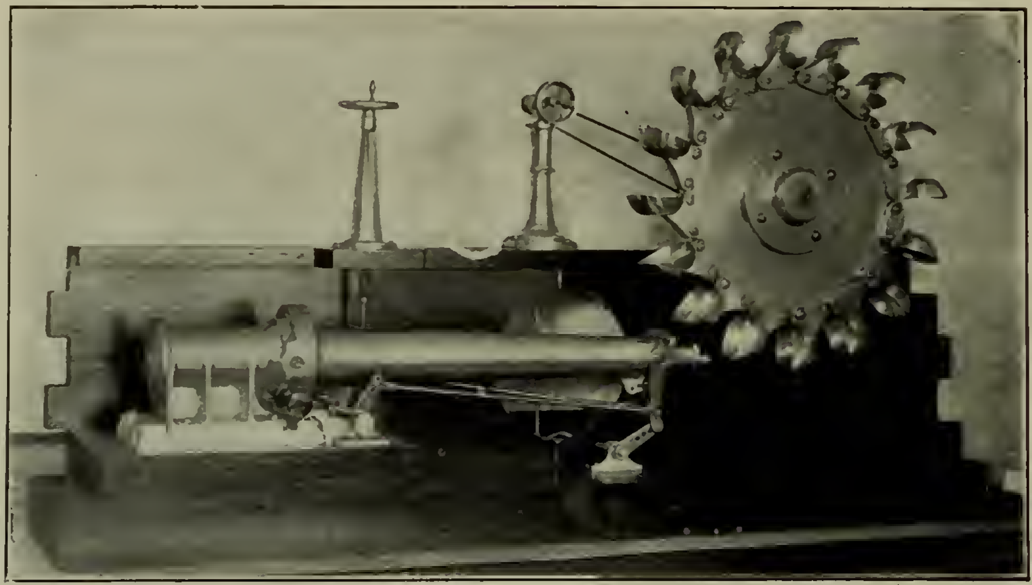


FIG. 2.—A PIVOTED DEFLECTING NOZZLE

ly desirable, the addition of fly-wheels with the necessarily increased windage and bearing friction are not in ordinary cases desirable. Governors of excellent design and machine construction are to be had from several manufacturers, so that the problem which confronts the engineer of to-day is usually that of properly adapting the apparatus that

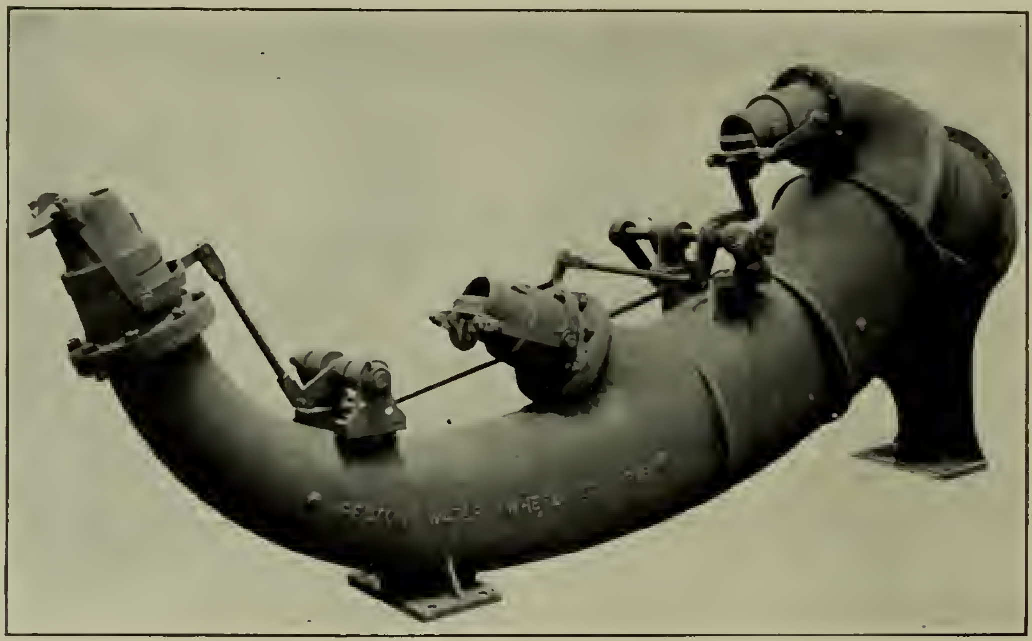


FIG. 3.—A TRIPLE NOZZLE, EACH OUTLET OF WHICH IS FITTED WITH A STEAM CUT-OFF

is readily obtainable to the conditions to be met with in any individual plant.

The general practice among turbine builders, as stated above, is to control the speed of their turbines by cylinder or wicket gates, either device aiming to limit the orifice of discharge without varying the spouting velocity, and, therefore, maintain high fractional load efficiencies, although neither of these devices do this perfectly. They both are open to the defect of causing a variation in the velocity of flow in the pipe line, and, therefore, a corresponding water ram every time the governor checks the velocity.

There is not, ordinarily, any trouble experienced, except in cases of extremely low head, due to the governor opening the gates too quickly and the water not getting up to spouting velocity quickly enough; but there is frequently very great damage caused by the governor shutting the gates so fast that the pipe or the turbine case is ruptured by the resulting water ram. In order to guard against this, it is customary to install safety valves, which usually are out of commission, owing to their requiring too great an increase in pressure in order to actuate them, or due to their freezing or becoming stuffed up with leaves, sticks, and the like, carried by the water.

Where there are a number of turbines fed by the same penstock, the water ram, due to a single machine closing, is not so serious as where there is but one or two on the same line; but the resulting change in spouting velocity, due to the monetary water ram, is then an objectionable feature, tending to cause a further increase of speed variation.

With the Pelton type of water-wheel, where a stream of water issues at full spouting velocity from a nozzle and enters the double-curved surface of a suitably designed bucket, its velocity is almost entirely taken up and the water caused to discharge from the sides of the water-wheel buckets at zero velocity. This type of wheel readily lends itself to a construction utilizing a deflection of the stream of water from the buckets in order to reduce the load that the wheel will carry at any instant of time. Such deflection can readily be accomplished without interfering with the spouting velocity of the water from the nozzles, by merely diverting the stream off or on the buckets. This can, of course, be done by pivoting the nozzles, or the nozzles may be made rigid and a stream deflector introduced into the jet in front of the nozzle tip.

Fig. 1 is a view of a Pelton wheel in operation when running at the correct speed, and shows one bucket just entering the stream of water; another bucket advanced to a mid-position and receiving the full impact of the jet, and the third bucket receiving the remaining portion of the jet, which has been cut off and is now flowing into the second bucket. The discharge from the sides of the buckets is clearly shown, and the fourth bucket, although not receiving water, is clearly shown to be discharging it, it having received its section of the stream which is still flowing over its interior surface and discharging from the outer edge. The photograph was taken with a special apparatus, the wheel being illuminated by an arc lamp in front of which is rotated a shutter exposing a ray of light at every instant that a bucket passes a given spot.

Fig. 2 is a model of a pivoted deflecting nozzle, which is arranged for moving up and down by the automatic governor, which is run by a suitable belt from the wheel shaft.

Fig. 3 shows a triple nozzle for application to a Pelton wheel, each outlet of which is fitted with a stream cut-off. These cut-offs vary the size of the opening, and, therefore, while not varying the spouting velocity of

the water issuing from them, vary its cross-sectional area, and consequently cause more or less water ram in the pipe line, but economize in water.

The objectionable feature of the deflecting nozzle is its wastefulness when operating the plant at less than full load, and the objection to the cut-off is that it exposes the pipe line to constantly recurring shock exactly the same as a turbine gate.

In order to economize with water and secure accurate governing, it has been the custom in recent years to install a combination needle and deflecting nozzle. The needle nozzle is one in which a suitable curved central core is provided to direct the stream of water issuing from the nozzle, the nozzle tip being also curved to properly direct the stream over this surface. Such a nozzle is shown in Fig. 5, the needle projecting beyond the surface of the nozzle tip; and in Fig. 4 the needle is shown through the transparent stream of water issuing from the nozzle. This particular nozzle is operating under a 390-foot head, and has a capacity of 1500 horse-power.

It is obvious that if we regulate the position of the issuing stream by a suitable governor acting on a deflecting nozzle or a stream deflector, we may actuate this governor as quickly as we choose without interfering with the safety of our pipe; and then if we vary the position of the needle in the nozzle we can vary the cross-sectional area of the issuing stream, and thus save water, this, of course, being done at such a speed as not to cause a dangerous increase in the running pressure. In following this course we must, however, avoid closing the needle to such a point that when a sudden load comes on and the governor raises the nozzle into the wheel, there will not be sufficient water to generate the required power.

In practice, the combination needle and deflecting nozzle is used by setting the needle to a point corresponding with the peak, which is likely to occur during each hour, and then allowing the governor to take care of the speed variations up to this peak. By this course some water is naturally wasted, but there is also a very considerable saving effected, and, except in the largest plants, it would hardly be worth while to install special automatic apparatus for effecting a further saving.

To handle these large needles and also these large deflecting nozzles quickly, requires a very considerable amount of power. Two such nozzles as shown in Fig. 4 require about 12,000 foot-pounds, and when operating under 890 feet of effective head are capable of developing upward of 10,000 horse-power from the two water-wheels, which are mounted on a single shaft.

In order to further reduce the power required to handle these large nozzles, counterbalancing cylinders may be introduced under the nozzles, supplied by pressure either from the governor oil-pump system or from the main pressure pipe line, as shown in Fig. 6. It is, of course, advisable to keep all of the water pressure parts and governor operating parts, except the delicate mechanism, below the floor line, and it is customary to cover the pit in which they are located with sheet-steel grilled floor plates.

The curve in Fig. 7 will give some idea of the amount of water saved by using the combination needle and deflecting nozzle. The amount of water required to handle the plant, if we had an absolutely perfect gate-operating mechanism,—that is, one in which the water quantity would be directly proportional to the kilowatts delivered from the generator,—would be shown as the area within the curve *A*. The amount of water required by the needle deflecting

FIG. 4.—A NEEDLE NOZZLE, HAVING A CAPACITY OF 1500 HORSE-POWER AND OPERATING UNDER A 390-FOOT HEAD

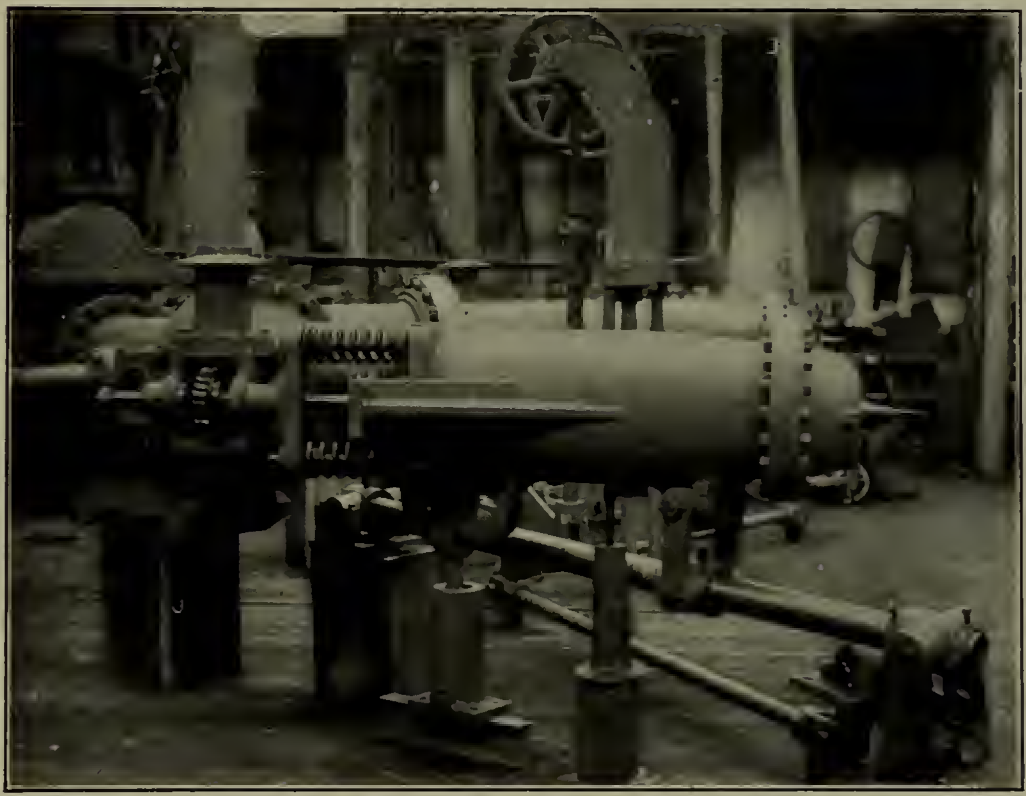


FIG. 5.—A NEEDLE NOZZLE, SHOWING THE NEEDLE PROJECTING BEYOND THE SURFACE OF THE NOZZLE TIP

nozzle where the needle is set to the peak that will occur within any hour, is shown by the curve *B;* and the amount of water that would be required if we used a straight ordinary deflecting nozzle would be that included in the entire parallelogram *C*.

Of course, the difference between *B* and *C* may be turned into a reservoir and result in the power company selling a greater output from their plant, using the same original water supply. Such an approximately increased output curve is shown by the line *D*. In order to save the water quantity between *A* and *B*, it has heretofore been necessary to sacrifice the safety of the pipe line by using a governor acting directly on the needle nozzle; and in order to compensate for this additional risk as far as possible, it is advisable to use safety water relief valves. Such relief valves, if of any value, will, of course, permit the escape of some water from the pipe line whenever the governor closes the gate quickly, and will accomplish the same result as setting the needle of the deflecting nozzle by hand at more frequent intervals, thus drawing the curve *B* closer and closer to the curve *A*.

In the average installation, even although water economy is important, it would hardly pay to introduce expensive or complicated devices for the purpose of taking care of this slight saving between curves *A* and *B*. On the other hand, power plants are becoming larger, and water power more expensive to develop, making the value of water greater, and making the units of much larger capacity, thus allowing the introduction of comparatively few automatic devices to save a quantity of water corresponding with a much greater horse-power than was possible a few years ago.

An automatic by-pass nozzle will accomplish the desired result with the best success. This consists of a needle nozzle similar in general construction to that shown in Fig. 5, except that the needle is pulled back from or advanced into the tip by the governor, thus allowing a greater or less flow of water on the buckets of the water-wheel; and coincident with the needle's action a by-pass is operated admitting a discharge of water from the nozzle body when the effective stream is reduced. This discharge of water is only momentary, the by-pass valve immediately starting to slowly close, its rate of closing being dependent upon the length of the pipe line and the permissible rise of pressure above normal.

Such a device is shown in Fig. 8. It will be noticed that its successful operation does not in any way require or depend upon the rise in pressure, due to the water ram, but is entirely independent of this. Moreover, the by-pass for the dash-pot cylinder is arranged with a double valve, so that when an increased load comes on the water-wheel the nozzle is quickly pulled back, the oil in the by-pass cylinder then being allowed to return to the front compartment with much greater rapidity.

This device, therefore, secures for us the best possible regulation by quickly varying the effective stream's cross-sectional area, which is attained with the greatest degree of safety to the pipe line by preventing water ram. It can also be handled by a comparatively light governor, as the parts can be well balanced and require a very small amount of power to handle them. This by-pass nozzle can, of course, be built in a number of ways, but Fig. 8 shows one of the best and simplest constructions for it.

It is obvious that if we eliminate the dash-pot cylinder and properly construct the curves of approach to the by-pass outlet, we can then vary the cross-section of our effective stream without interfering with the velocity of flow in the pipe line, permitting whatever water may be cut down from the effective stream to discharge through the by-pass outlet. In this way is secured, if necessary, a constant rate of discharge through the nozzle, and at the same time accurate regulation on the water-wheel is obtained.

In practice, however, if it is desired to attain this object, deflecting nozzles will probably be found more satisfactory. They may be readily counterbalanced by weights, or in

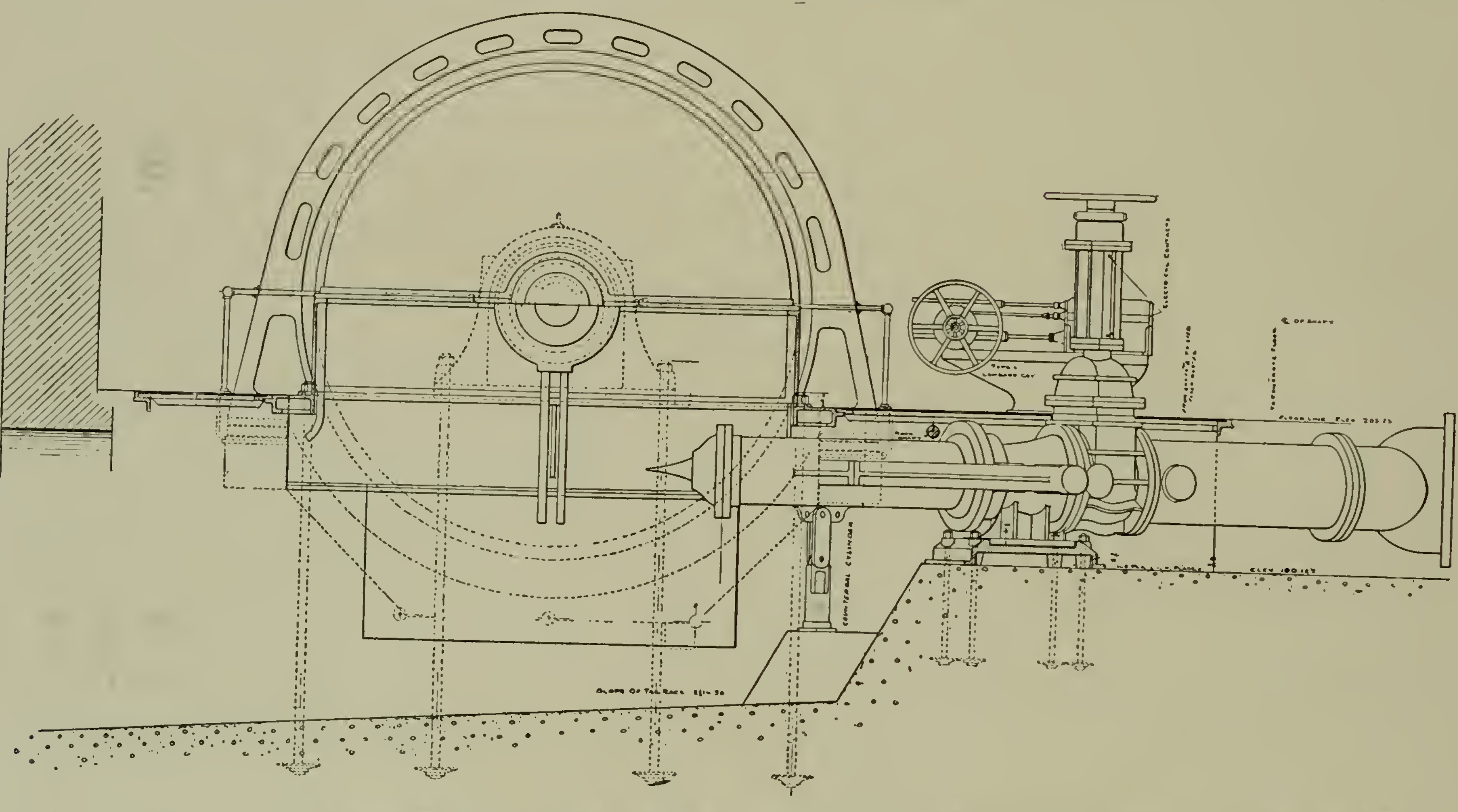


FIG. 6.—GENERAL VIEW OF THE ARRANGEMENT OF A PELTON WHEEL WITH A LARGE DEFLECTING NOZZLE, SHOWING THE COUNTERBALANCING CYLINDER USED FOR REDUCING THE POWER REQUIRED TO OPERATE THE NOZZLE

large installations by hydraulic or oil pressure through suitable cylinders arranged immediately under the nozzles. They do not in any way interfere with the flow of water in the supply pipe, nor can any damage that would in ordinary practice occur to them be likely to cause any interference with this.

When the deflecting nozzle is used for speed regulation we may rest assured that we are obtaining the maximum safety of our pipe line. The connections for operating such a deflecting nozzle as installed in most of the best plants are shown in Fig. 4, where tension rods, operating through suitable bell cranks and universal joints, raise and lower the two deflecting nozzles operating on the two wheels of a single unit, such control being effected by a single governor. In the case of a 10,000 horse-power unit operating under an 890-foot head, about 12,000 foot-pounds are required to properly move these nozzles; and in order to secure good regulation, this work has to be performed in from two to two and one-half seconds, the generators carrying a railway and gold-dredger load.

However well this apparatus may be constructed, there is a sufficient amount of lost motion to prevent their accurately arriving at the position demanded by the governor; and, therefore, when the parts have once come to rest, the wheel speed may be, at times, sufficiently removed from the normal speed to cause the governor to again shift them. This lost motion, therefore, has the effect of causing the governor to "hunt," although within narrow limits,—in practice within the 2 per cent. already mentioned. Again, it is quite expensive to properly construct and care for these heavy rock shafts, and their lubrication is quite an important feature.

In order to correct these defects, particularly in large plants having a number of units, the construction shown in Fig. 9 is advised. In this case, each nozzle is entirely controlled by a pressure cylinder located immediately over or under it, and, if desired, a separate cylinder may be used for counterbalancing the nozzle weight, or the operating cylinder may be made of the differential type. This construction permits the removal of all the expensive connections heretofore located between the governor and the nozzles, thus eliminating the difficulties experienced, due to lost motion and the large expense involved.

The governor is of the usual type and admits pressure fluid, usually a special mixture of oil, into one side or the other of the nozzle operating cylinder, thus raising or lowering the nozzle without the intervention operated on the other side by the fly-balls actuating a small controlling piston valve.

In order to properly synchronize

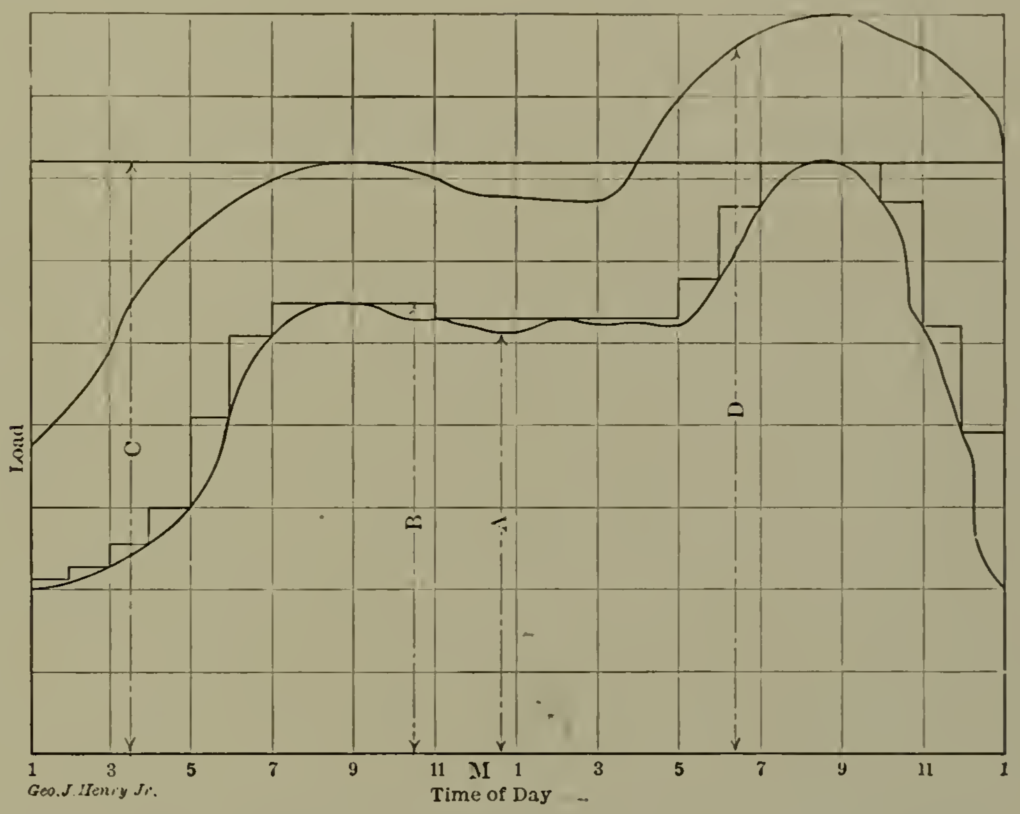


FIG. 7.—CURVES SHOWING THE AMOUNT OF WATER REQUIRED BY THE DIFFERENT NOZZLES

of other connecting means than a pair of links. The governor may be located above the floor line and the piping connections carried to the cylinder under the nozzles. As the nozzle moves to take up its new position, it actuates through a small connecting rod a piston located in a number of machines, a small, reversible motor may be located on the governor connections and actuated from push buttons on the switchboard, this motor lengthening or shortening the pilot valve stem, which is actuated by the fly-balls. This will enable the operator to start

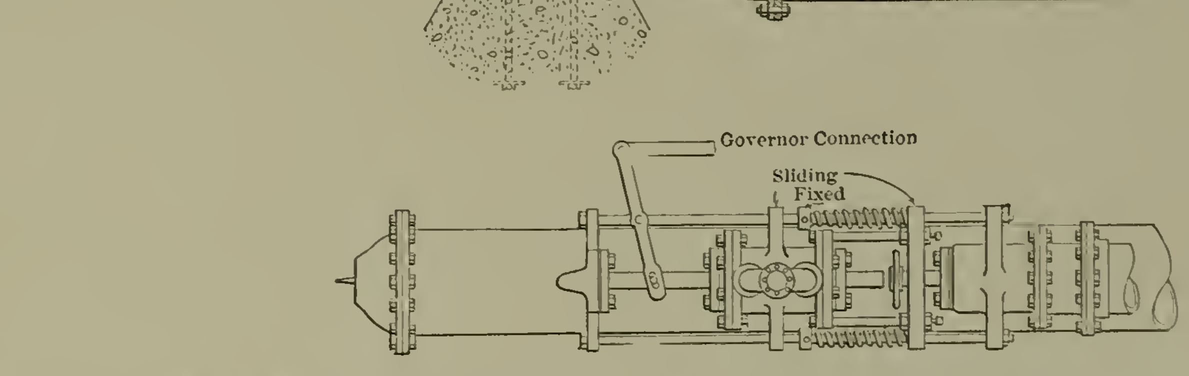


FIG. 8.—AN AUTOMATIC BY-PASS NOZZLE. THE NEEDLE IS OPERATED BY THE GOVERNOR, AND WHEN THE EFFECTIVE STREAM IS REDUCED THE BY-PASS ALLOWS A DISCHARGE OF EXCESS WATER FROM THE NOZZLE BODY

a displacement cylinder, which displaces a small amount of oil, and thus resets the piston valve which controls the flow to the operating cylinder, this piston valve being up the wheel from the switchboard by gradually raising the effective stream into the wheel by shifting the valve stem, and thus permitting oil to flow to the outside of the operat-

ing cylinder. In all modern plants a number of units are operated in synchronism, feeding into a single set of bus-bars. Therefore, all of the units run at absolutely the same speed, regardless of the position of the nozzles, and unless the nozzles are all about of the same relative position, one of the units carries a greater amount of load; or unless the governors are adjusted exactly right, some of the nozzles are likely to be entirely deflected and their machines running as motors.

It is, therefore, advised that there be arranged a single governor driven by a small synchronous motor, which in Fig. 9 is shown belted to the governor for the sake of clearness. This should in practice, however, be direct-connected and mounted on the governor table, the governor being provided with a suitable set of valves and accessory operating cylinder and relay and relay-returning devices. Any variation in speed that occurs on the main unit instantly causes a corresponding speed change in the governor balls and causes the governor to shift its piston an amount corresponding with the change which will be required in the setting of all the nozzles, in order to properly adjust them to the new load requirements.

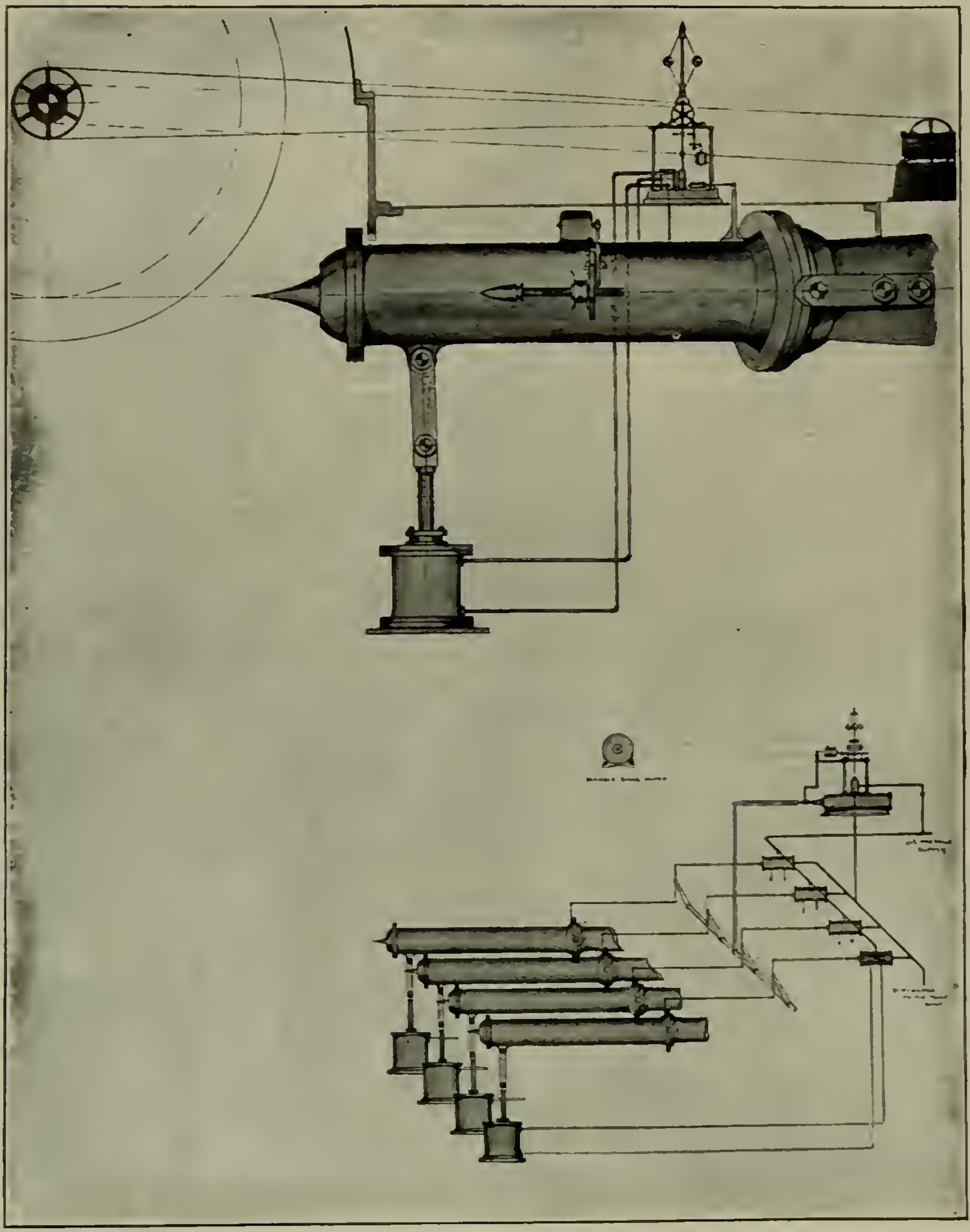


FIG. 9.—CONSTRUCTION IN WHICH EACH NOZZLE IS CONTROLLED BY A PRESSURE CYLINDER IMMEDIATELY ABOVE OR BELOW IT, AND IN WHICH A SINGLE GOVERNOR IS DRIVEN BY A SYNCHRONOUS MOTOR

This governor piston shifts the long vertical lever shown in the figure, thus operating the four pilot valves which admit pressure fluid to one side or the other of the operating cylinders located under each nozzle. All the nozzles, being controlled by this single governor, will then move, although it is not necessary that they should move at the same speed or that they should require the same amount of work to move them.

Each nozzle as it moves will gradually shift the pilot valve piston back into its original position, through the action of the floating levers, until the ports of the nozzles' operating cylinders are again closed. All the nozzles will, therefore, take up a position exactly corresponding with each other, and their position may be indicated above the floor line by the position of the long, vertical lever connected with the governor piston.

It will be observed that an adjustment can readily be provided on the rods connecting the floating levers with the pilot valves to adjust the pilot valve setting with respect to its own nozzle, thus enabling the station operator to unequally distribute the load on the different units, or in starting to properly synchronize them.

If desired, the same apparatus may be applied to stream deflectors, the operating cylinders shown in the figure under the nozzles being then arranged to shift the stream deflectors. Such an automatic counterbalanced stream deflector is shown in Fig. 10. The interior surface of the stream deflector is curved, so as to secure a reaction equal to the pressure, thus enabling this device to be moved into or out of a very large high-pressure stream with an extremely small effort.

The operating cylinders may be arranged to move the needles in or out of the nozzles, or they may be applied to the by-pass nozzles mentioned before; in any event, the entire plant may be operated from a single small governor, located at the most convenient point in the power house, thus doing away with a large amount of expensive apparatus, and, what is more, simplifying the design throughout and securing better regulation. The common rock shaft which shifts the floating levers should, of course, be made of such size as to practically eliminate torsion, but to properly handle the largest nozzles will require but a very few foot-pounds of work as against many thousands heretofore; so that this is a point easy of attainment.

It will, of course, be noticed that the use of the needle and deflecting nozzle does not provide a means of suitably governing turbine plants, and the present state of the art is such that the use of safety valves is almost absolutely necessary to properly protect the pipe line when governing turbines on railway and other rapidly fluctuating loads. Such a valve is shown in Fig. 11.

In this design a double-beat safety valve is provided on the main pipe line, both valves being held securely on their seats by fluid pressure entering a cylinder and exerting a heavy pressure on the piston, which is directly connected with them. The removal or reduction of this cylinder pressure will serve to re-

lease, with greater or less rapidity and to a greater or less degree, the double valve from its seats, thus allowing a suitable discharge of water

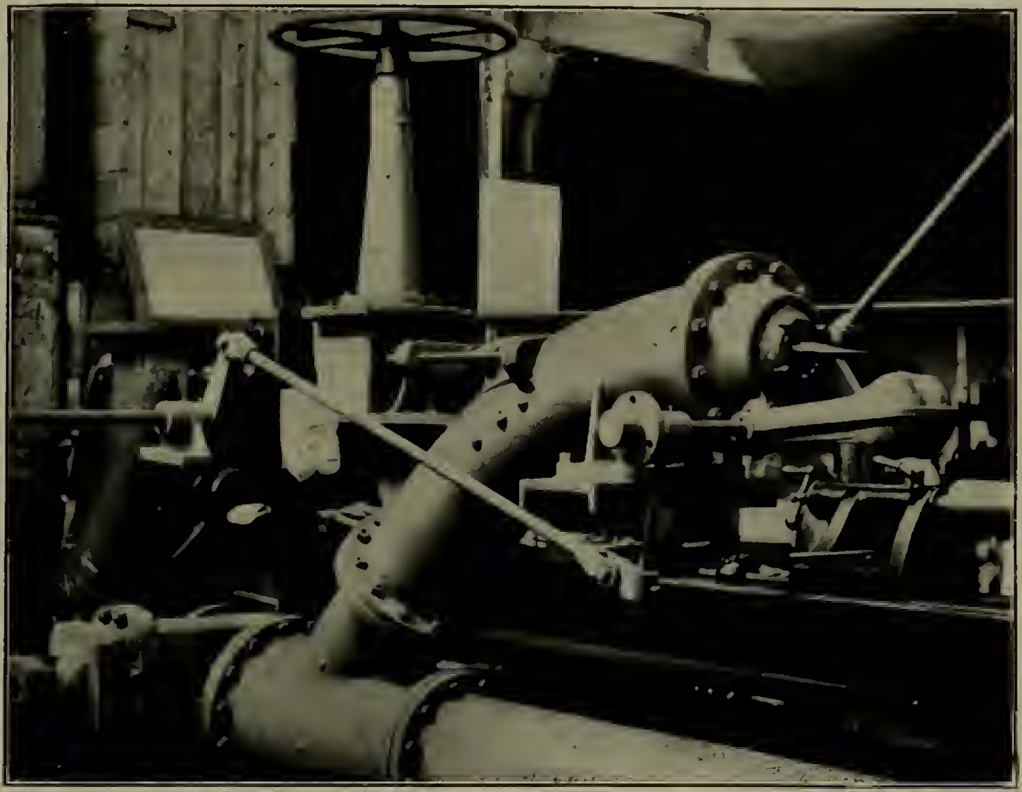


FIG. 10.—IN ONE TYPE OF NOZZLE AN AUTOMATIC DEFLECTOR IS MOVED IN AND OUT OF THE STREAM

from the main pressure line to relieve the water ram.

It is, therefore, necessary for us to

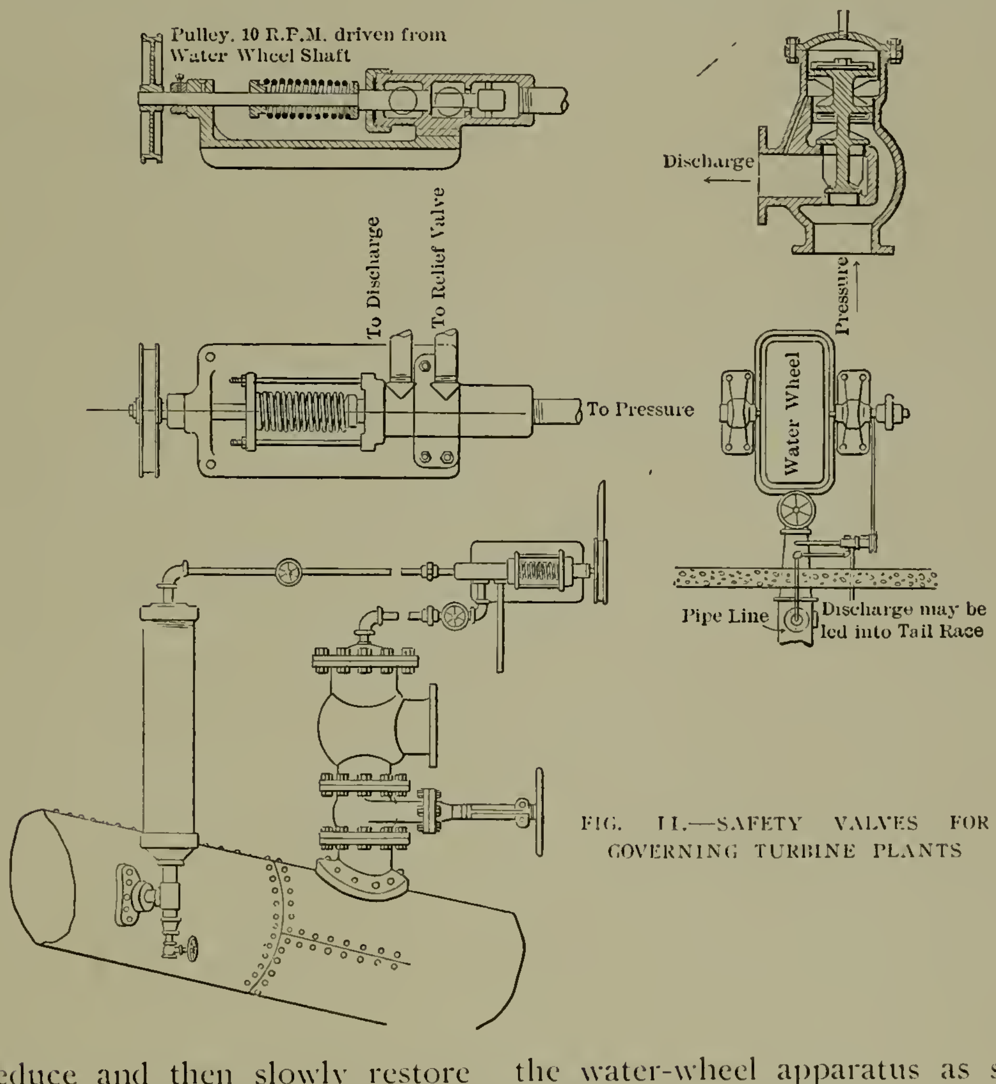


FIG. 11.—SAFETY VALVES FOR GOVERNING TURBINE PLANTS

first reduce and then slowly restore the pressure in the top cylinder, if we desire to relieve the water pressure in the main pipe line. In order to accomplish this a connection is made from the main pressure line to a rotating pilot valve. This pilot valve is shown in section and plan in Fig. 11, the central side outlet being connected to the cylinder in the top of the discharge valve shown in Fig. 9, all being arranged in connection with the water-wheel apparatus as shown in the lower diagram.

It will be observed that water pressure against the end of the piston in the pilot valve tends to compress the adjustable spiral spring, and the piston takes up an intermediate position just sufficient to maintain pressure on the piston of the double-beat safety valve. If now an increase in pressure occurs in the main line, the pilot-valve piston is driven forward, closing the pressure connections from the relief valve and allowing the relief valve to operate through the pilot-valve port to the discharge pipe, therefore instantly relieving the pressure which maintains the double-beat valve in its closed position, allowing the valve to open and free the pipe line of its excess pressure.

As soon as the excess pressure is properly relieved and normal pressure restored by the escape of the water through the double-beat valve, the pilot-valve piston returns to its original position of cutting off the discharge from the relief valve, and restores the connection between the relief-valve cylinder and the main pipe, thus closing the relief valve.

It will be seen that the action of this valve is very positive, and yet its operation occurs within extremely narrow limits of pressure variation, if the spiral spring is suitably adjusted for this purpose. The piston is continually rotated from the water-wheel shaft or other source of motion, in order that it shall more quickly respond to pressure variations and not by any possibility stick in the packing gland.

A feature of advantage in this connection is that a very small quantity of pressure fluid is used for operating the safety valve,—not more at any time than the volume of the cylinder. Therefore, a very small velocity occurs in the pipe leading from the main pipe line to the pilot valve, and there is consequently a very much less chance of its becoming plugged up with leaves, sticks, and the like. A settling chamber may be introduced in this pipe line with a suitable blow-off valve, if the water is likely to carry material which would in any way interfere with its operation.

As a further precaution, the connection to the pilot valve may be taken from the side of the pipe instead of the top or the bottom, thus avoiding material that would float or that would sink in the water column traversing the main pipe. A valve of this type with its pilot-controlling mechanism is, of course, more expensive than the ordinary spring-actuated safety valve, but it can be depended upon to give very much more accurate regulation, and is a much better protection to a pipe line than a spring-actuated valve.

Reduction of Fare to the Atlantic City Convention of the National Electric Light Association

IN a circular issued by George F. Porter, master of transportation of the National Electric Light Association, the following instructions are given for the purchase of tickets to the Atlantic City convention, to be held from June 5 to 8:—

A rate of fare and one-third, on the certificate plan, has been secured. Tickets at full fare for the going journey may be secured not earlier than June 1 nor later than June 7, good to return until June 12. Be sure to ask for a certificate when purchasing the going ticket.

Certificates are not kept at all stations. If inquiry is made at a station, the agent will designate the station at which they can be obtained. A local ticket can be purchased to such a station, and the certificate and through ticket secured there.

On members' arrival at the meeting, certificates should be presented to George F. Porter, Young's Pier, to be viséd.

It has been arranged that the special railroad agent will be in attendance to validate certificates on June 5, 6, 7 and 8. A fee of 25 cents will be collected for each certificate validated.

From California and North Pacific Coast points regular nine months' tourist rates (about one and one-third fare for round trip) are in effect daily to the following points:—

Atchison, Kan.	Memphis, Tenn.
Cairo, Ill.	Minneopa, Tex.
Chicago, Ill.	Minneapolis, Minn.
Council Bluffs, Ia.	New Orleans, La.
Denver, Col.	Omaha, Neb.
Fort Worth, Tex.	St. Joseph, Mo.
Houston, Tex.	St. Louis, Mo.
Kansas City, Mo.	St. Paul, Minn.
Leavenworth, Kan.	

At any of the above points, certificate plan tickets can be bought to Atlantic City, making the round trip from California and North Pacific Coast points approximately a fare and one-third.

Further information can be secured from the following:—

C. O. Simpson, Little Rock Railway & Electric Company, Little Rock, Ark.

W. J. Barker, Denver Gas & Electric Company, Denver, Col.

C. H. Hodskinson, 70 State street Boston, Mass.

A. H. Manwaring, Tenth and Sansom streets, Philadelphia, Pa.

A. F. Giles, Empire Building, Atlanta, Ga.

J. W. Cunningham, Capital Electric Light, Motor & Gas Company, Boise, Idaho.

Frank L. Perry, Marquette Building, Chicago, Ill.

F. S. Hunting, Fort Wayne Electric Works, Fort Wayne, Ind.

J. H. DeGrange, New Orleans Railway & Light Company, New Orleans, La.

E. F. Phillips, Peninsular Electric Light Company, Detroit, Mich.

H. J. Gille, St. Paul Gas Light Company, St. Paul, Minn.

A. G. Monroe, secretary Nebraska Electric Company, Omaha, Neb.

W. R. Huntley, Buffalo General Electric Company, Buffalo, N. Y.

F. H. Gale, General Electric Company, Schenectady, N. Y.

H. W. Plummer, Asheville Electric Company, Asheville, N. C.

W. J. Hanley, 409-410 Columbus Savings & Trust Building, Columbus, Ohio.

J. J. Cagney, Montreal Light, Heat & Power Company, Montreal, Can.

W. E. Swayze, Junction City, Kan.

Samuel G. Reed, Seventh and Alder streets, Portland, Ore.

J. C. McQuiston, Westinghouse Companies, Pittsburg, Pa.

W. W. Fuller, Charleston Railway, Gas & Electric Company, Charleston, S. C.

J. R. Cox, Brush Electric Light & Power Company, Galveston, Tex.

John Montgomery, Jr., Utah Light & Railway Company, Salt Lake City, Utah.

W. S. Heger, Allis-Chalmers Company, Milwaukee, Wis.

H. G. Nicholls, 14 King street, East, Toronto, Can.

F. B. Blankenship, Virginia Passenger & Power Company, Richmond, Va.

George F. Porter, 120 Liberty street, New York City.

Present and Future Conditions at Niagara Falls

THE American members of the International Waterways Commission, in their report regarding the present condition of Niagara Falls and its future state if no check be made upon the present plans for utilizing the water, recommended that the Secretary of War be authorized to grant permits of 28,500 cubic feet per second, and no more, from the waters tributary to Niagara Falls, distributed as follows: —Niagara Falls Hydraulic Power & Manufacturing Company, 9500; Niagara Falls Power Company, 8600; Erie Canal or its tenants (in addition to lock service), 400; Chicago Drainage Canal, 10,000.

They also recommend that all other diversion of this water be prohibited under penalty, except as may be required for domestic use, or for locks in canals; that this prohibition remain in force two years; and that it then be made a permanent law, if in the meanwhile the Canadian Government shall have enacted a similar legislation placing their maximum diversion of water at 36,000 cubic feet per second.

It is thus seen that Canada would then have the advantage of diverting 7500 cubic feet of water per second more than the United States, but as the majority of the power generated on the Canadian side would be transmitted to and used in the United States, the advantage is more apparent than real. It is assumed, however, that an understanding regarding this matter would be reached by treaty.

The amount of water allowed Canada was fixed so as to permit the Canadian companies who now have works under construction to use the amounts for which they were designed. These companies and their respective allowances are as follows: —Canadian Niagara Power Company, 9500; Ontario Power Company, 12,000; Electrical Development Company, 11,200; Niagara Falls Park Railway Company, 1500; Welland Canal or its tenants (in addition to lock services), 1800.

The Canadian members of the commission, while agreeing substantially with the statement of facts in the American report, contended in their report that if the Falls are impaired in beauty to-day, the mischief is done on the American side, as the power companies on the New York side have their intakes above the rapids; whereas of the three Canadian companies, one,—the Ontario Power Company,—takes water at the crest of the Falls, and the other two below the crest.

The Canadian report also advises the government not to make any treaty with the United States regarding Niagara alone, but that the treaty must embrace all the waters adjacent to both countries, from the Pacific to the Atlantic oceans. It also suggests that the duration of the treaty should not exceed thirty years.

Telephone stations for selling New York theatre tickets have been established in New Rochelle and Mount Vernon, N. Y., and in Newark, N. J. The operator at each station has seating plans of the theatres interested, the orders are telephoned to the theatres, and the tickets are sent by mail or held at the theatre.

Ratio in Vapour Converters

By PERCY H. THOMAS, Chief Electrician of the Cooper Hewitt Electric Company

THE question is often asked, "What is the ratio of a vapour converter?" As here used, the term "ratio" is not capable of being defined in a definite rule applicable to all cases. The reason will become evident from what follows:—

VOLTAGE RATIO

The voltage ratio of a static transformer is the ratio of the primary to the secondary turns, and has no ambiguity. The ratio of a rotary converter is by no means as definite. The effective ratio of the alternating-current voltage to the direct-current voltage is different in a two-phase rotary converter from what it is in a three-phase converter, and, further, will differ in a minor degree with the wave form. The calculation of the ratio in any given case is a comparatively easy matter, however, to a designer having the proper data. Similarly with a vapour converter. Its ratio varies with the conditions of each individual case. By analyzing carefully the method of operation of a vapour converter, we can readily determine the ratio under any given conditions.

For the purposes of discussion, we will consider that the ratio of a vapour converter is the direct-current voltage of the receiving circuit divided by the alternating-current voltage applied. We may consider either the ratio due to the bulb itself or of the whole apparatus required for the transformation.

Consider Fig. 1, in which *AB* is an auto-transformer connected across the supply. We have during one alternation an electromotive force in *A* equal to one-half the voltage impressed across the two positive electrodes, which electromotive force we will assume is passing current in the direction shown by the arrows to the converter and the load. During the next alternation we have a similar electromotive force in *B*, passing current again in the direction of the arrows through the bulb and the load. Since everything is symmetrical, the result is the same as if we omitted the bulb and had a pulsating electromotive force of the value of that in *A*. applied directly to the receiving circuit.

In this case, if we use an alternating-current voltmeter which shows the "effective" values of a given electromotive force wave, such as a dynamometer or induction type meter, and if the supply electromotive force be a true sine curve, we shall have a reading upon the voltmeter across the supply of 0.7071 times the maximum value of the supply voltage. During operation the voltage of the supply is absorbed partly by the choke coil *K* and partly by the load *L*, and, of course, partly by the bulb itself, which, however, may be assumed to abstract a constant value of 15 volts under all conditions. The coil absorbs energy and voltage on a rising current, and delivers energy, and adds voltage to the circuit, on a falling current. In all cases, regardless of the wave form, the energy absorbed by the coil must be equal to its energy delivered to the circuit, neglecting coil losses.

Since the voltage on the coil is proportional to the rate of change of the current, during any complete cycle the average coil voltage must be zero as the current returns to its original value. That is to say, when we are using meters measuring the average value of the voltage, such as the Weston standard direct-current type, the choke coil neither adds nor subtracts from the available voltage of the supply. The chief function of the choke coil is to control the fluctuations of the current, incidentally preventing its dropping to zero between the alternations of the supply.

We are now ready to consider the ratio of the apparatus under different conditions. In what follows we will neglect converter and coil losses and assume the supply to be of infinite capacity, so that it will experience no drop due to flow of current; also that the supply electromotive force wave is a true sine curve.

CONDITION NO. 1

This condition is that of a resistance load and a choke coil large enough to give a substantially uniform value of the direct current. In this case the voltage of the supply is, as we have already stated, 0.7071 times its maximum value as measured on an instrument which indicates the effective value of the wave. The voltage in the receiving circuit is evidently constant, since we have a constant current flowing in a constant resistance, and it will be equal to the average value of the supply on account of the averaging power of the choke coil. The average value of a sine curve equals 0.6366; therefore, the ratio of the outfit in this case is $\frac{1}{2} \times 0.6366 \div 0.7071 = \frac{1}{2} \times 0.9003$.

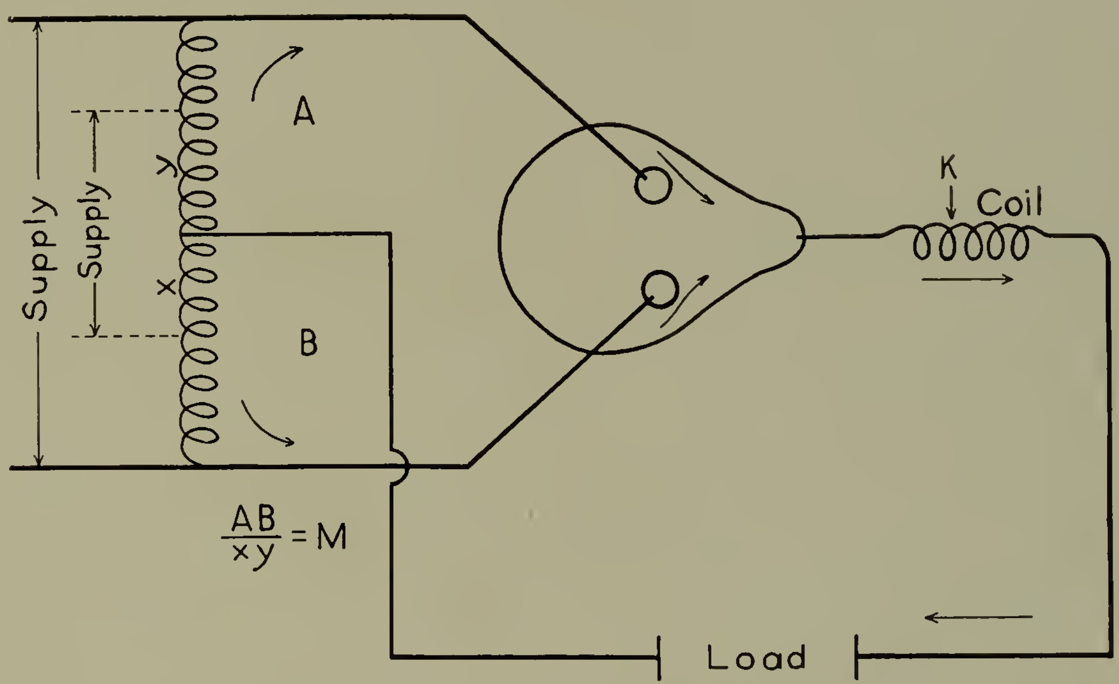


FIG. 1.—A VAPOUR CONVERTER WITH AN AUTO-TRANSFORMER ACROSS THE SUPPLY CIRCUIT

The factor, $\frac{1}{2}$, is introduced since only half the supply voltage is used at any one time.

It must be noted that should the voltage of the supply be different from that required across the positives of the converter, so that a transformer or auto-transformer be used for raising or lowering the supply voltage at $X\ Y$ in Fig. 1, the ratio of the converter as just determined must be multiplied by the ratio of transformation of the voltage across the positives of the converter to the supply. If this ratio be M, the ratio of the total outfit will be $\frac{1}{2} \times 0.9003\ M$. In the load voltage must be included the 12 to 15 volts absorbed in the bulb itself, and all losses in the coil, etc.

CONDITION NO. 2

This condition is that of a resistance load and no choke coil. In this case it is assumed that some means other than the coil are used to keep the converter "alive." Here we have in the load a pulsating current corresponding exactly (neglecting the 15 volts on the bulb) to the supply electromotive force. We shall evidently have the same reading on the voltmeter in the supply as in Condition No. 1, that is, the effective voltage. If we use the same type of instrument on the load we will get the same voltage reading, that is, the ratio is unity, or, if we consider as the supply the voltage across the positives, the ratio equals $\frac{1}{2}\ M$.

If we use a voltmeter which gives us the average value of the voltage instead of the effective value, for measuring our load voltage, we then have our ratio as in Condition No. 1, since it is the ratio of the average to the effective value of a sine electromotive force curve; that is, the ratio equals $\frac{1}{2}\ M$, if we measure with instruments indicating effective values, and the ratio is $\frac{1}{2} \times 0.9003\ M$ when using in the load an instrument indicating average values.

CONDITION NO. 3

This condition is that of a constant electromotive force in the load, such as a Cooper Hewitt vapour lamp or a storage battery, and a choke coil sufficiently powerful to give a perfectly smooth current wave. We have here the same ratio as in Condition No. 1, but in this case we have a constant load electromotive force exactly equal to the supply, which is an impossible condition since the current may be anything from zero to an infinite amount. In such cases it is always necessary to have a certain amount of voltage "backing," i. e., voltage taken up by resistance or inductance, or its equivalent in series with the constant voltage load. In determining the ratio of the outfit under this condition, the percentage of the voltage taken up by resistance or inductance must be considered, that is, the useful ratio $= \frac{1}{2} \times 0.9003\ M\ P$, where P is the fraction of the available load voltage not taken up by the series inductance or resistance.

It is evident if the supply voltage and the working voltage remain unchanged, that the ratio of the outfit will be unchanged with varying currents. This results from the fact that to get a variation in current it is necessary to make a corresponding variation in the amount of resistance or impedence used as backing. This change is necessarily always of such a nature as to keep the voltage absorbed by the backing the same,—it must always equal the difference between the load and the supply.

CONDITION NO. 4

Finally, we have a constant voltage load and no coil. Since there is no choke coil, means must be provided for keeping the negative electrode broken down. Evidently we shall have an intermittent current in the load, since only at certain portions of the cycle will the alternating voltage of the supply be higher than the constant voltage of the load. In this case it is impossible to give a general statement of the ratio, since a variety of work circuit voltages may be supplied from the same supply voltage and the current still controlled. The different work circuit voltages in this case will represent different degrees of intermittency in the current. Voltmeters will measure the voltage of the supply on one hand, and the voltage of the work circuit on the other hand, but will take no account of during what portion of the cycle current is actually being transmitted.

From what has been so far said, it is evident that the ratio as determined by meters depends directly on the character of voltmeter used in measuring the voltage, and the question naturally arises as to which is the proper instrument to use. This depends upon the use to be made of the current in the work circuit. If it is to be used in running incandescent lamps, for example, where the total energy received is the important item, an instrument indicating the effective values would be proper. On the other hand, in the case of a receiving device, depending for its function upon the total quantity of current, such as a storage battery, an instrument averaging the voltage might properly be used, though there will be cases where the effective value will be desired. Where the choke coil very nearly steadies the current it makes little difference which type of instrument is used.

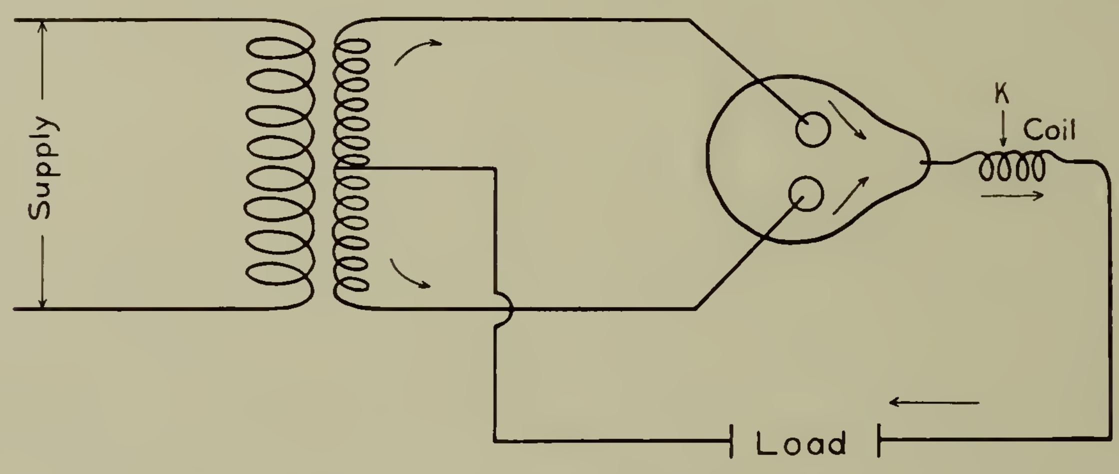


FIG. 2.—A VAPOUR CONVERTER WITH A TRANSFORMER HAVING SEPARATE PRIMARY AND SECONDARY WINDINGS ACROSS THE SUPPLY CIRCUIT

CURRENT RATIO

The ratio of current is a different matter from the ratio of voltage, and must be gotten at, as in the case of the voltage ratio, by an analysis of the method of operation of the converter. Referring to Fig. 2, which shows the converter in operation as in Fig. 1, except that a transformer with separate primary and secondary windings is used instead of an auto-transformer, it will be seen that current flows alternately in the two halves of the secondary.

At all times when the current in either half of the secondary is zero, we must have the same number of ampere-turns in the primary as in the other half of the secondary. Consequently, the ratio of the current in the primary to the current in the secondary (which is also the current in the work circuit) is at $\frac{1}{2} \times R$ to S, where R is the total number of turns in the secondary between the positive electrodes, and S the number of turns in the primary. At the

instant, however, when we have no electromotive force in the supply, and the choke coil L is supplying the voltage to maintain the current through the load, this current will evidently divide into two parts, flowing equally in opposite directions through the two halves of the secondary. This will neutralize the total magnetic effect of the secondary current on the primary and no current will flow in the supply.

During this period we then have current in the work circuit with no current in the generator. It is also evident if we have no inductance or resistance in the secondary of the transformer, or in the leads from there to the positives of the converter, that as long as any voltage remains in the supply, in a given alternation, current will continue to flow wholly in the operating side of the secondary; also, that as soon as any voltage whatever appears in the next alternation, the whole current will be transferred over to the other side. Consequently, we have only an instant at which the current divides between the two halves of the secondary in such a way as to take no current from the supply. Evidently, this does not disturb the ratio previously determined.

When, however, we insert resistance in the leads to the positives of the converter, we evidently prolong the period of transfer of current from one side to the other. That is to say, before the electromotive force in the operating side of the transformer secondary actually reaches zero, some current will pass through the opposite side of the secondary on account of the drop produced in the resistance introduced in the first positive lead. Similarly, current will not wholly leave the first half of the secondary until a sufficient voltage is reached in the next alternation in the supply to exceed the drop produced in the resistance in the second positive by the full current.

The net result is that some current flows through the load maintained partly or wholly by the choke coil, which does not appear at all in the supply as current, but which must alter the natural ratio between load and supply current. The energy thus represented, however, is secured only at the expense of a lower potential in the work circuit, due to the action of the resistance and the greater amount of energy absorbed and delivered by the coil.

In the case of inductance in the leads to the positives, the effect is similar, though somewhat different in that the transfer of current from one side to the other, instead of being symmetrical about the zero of the electromotive force, is delayed in such a manner as to cause current to flow in the supply for a certain period in a direction opposite to the supply electromotive force, resulting in a lowering of the power factor.

In most actual cases, however, the amount of current supplied to the load by the choke coil which does not appear in the supply is negligible, so that the ratio of the load current to the supply current is substantially $\frac{1}{2}\,\frac{S}{R}$, or putting as before, $\frac{R}{S} = M$, the ratio $= \frac{1}{2}\,\frac{1}{M}$. But here, again, we get into difficulty of measurement on account of the wave form of the current. On the direct-current side we will have usually a more or less pulsating continuous current, and we get its average or effective value according to the instrument used, while in the supply we have a true alternating current, but usually not one having a sine wave. The wave distortion will have an effect on the meter indications which will be different with different instruments and different actual wave conditions, so no general laws can be given.

If an auto-transformer be used in place of the transformer with separate primary and secondary as shown in Fig. 2, the ratio of current between the work circuit and the supply will be the same, but the current within the windings of the transformer will be the algebraic sum of the currents found in the case of the separate primary and secondary windings.

In the case of intermittent currents due to the omission of the choke coil in the negative, the fundamental ratio of transformation of current remains the same, but the distorting effect of wave form on the instrument characteristics may be somewhat increased on account of greater variation of wave form.

This discussion of ratio has been confined to the method of operation of the vapour converter shown in Figs. 1 and 2, with the modification involved in the omission of the coil. It is, of course, possible to operate these converters in other ways which will involve a different discussion of the ratio; for example, a three-phase converter will require no choke coil in many cases and will give a different ratio from the single-phase converter. Since the latter, however, is the form having the most convenient characteristics for present uses, this discussion has been confined to the single-phase type.

Foreign Visits of the American Institute of Electrical Engineers

THE American Institute of Electrical Engineers has received from the British Institution of Electrical Engineers further details in reference to the tour which the latter association is organizing for the entertainment of kindred institutions which will visit England during the coming summer.

It is assumed that visitors will make their own arrangements for traveling to London. After arriving there, the additional cost to any individual who takes part in the whole trip through Manchester, Glasgow, Newcastle, etc., and back to London, should not exceed from ten to twelve pounds or, say fifty to sixty dollars, including hotel and other expenses. This, however, does not include the stay in London, for which about five dollars a day additional should be allowed.

The Associazione Elettrotecnica Italiana has also extended an invitation to the Institute to visit Italy during the Milan Exposition. The visits contemplated by the Associazione include Naples, Rome, Florence, Genoa, Turin, Milan (Exposition) and Venice, and the time fixed by the Associazione is June 1 to 15. It is expected that the party will meet in Milan on June 1, spending several days there visiting the Exposition, and then undertake the circular tour above outlined with visits to the important transmission plants and the many points of interest along the route. It is expected that the expenses of the fifteen days' circular tour in Italy will be about the same as those of the English tour, or approximately $75.00.

An interval of a week has been left between the end of the Italian tour and the beginning of the English tour, thus enabling those who so desire, to spend the additional time in Italy, Switzerland or France before going to London.

Following is an outline of the programme for the British tour:—

June 23 and 24 (Saturday and Sunday)—Central committee rooms at the Hotel Cecil will be open for registration of visitors and members.

June 25 (Monday), Afternoon—A visit to the National Physical Laboratory may be arranged, to attend the ceremony of opening the new Electro-Technical Laboratory. In the evening, reception and banquet at the Hotel Cecil.

June 26 (Tuesday)—Visits to the General Post Office, power and electric lighting stations, railway and tramway power stations, engineering

works, telephone exchanges, and other undertakings and places of interest. In the evening, conversazione at the Natural History Museum.

June 27 (Wednesday)—Excursion up the Thames and visit to Windsor.

June 28 (Thursday)—Leave London for Birmingham District. The programme will include visits to works in and near Birmingham, including Rugby and Stafford. Arrive at Manchester in the evening.

June 29 (Friday), Manchester District—Visits to electricity stations and works in Manchester, Salford, and the neighbourhood. Conversazione at the Town Hall in the evening.

June 30 (Saturday)—Proceed to Liverpool, visits to electricity stations, works, and railways. Leave in the afternoon for the Lake District (Windermere).

July 1 (Sunday)—Excursions in the Lake District. Proceed to Glasgow in the evening.

July 2 (Monday), Glasgow District—Visits to works and reception by Lord Kelvin.

July 3 (Tuesday)—Visits and excursions in the neighbourhood of Glasgow.

July 4 (Wednesday)—Leave Glasgow for Edinburgh. In the afternoon leave Edinburgh for Newcastle.

July 5 (Thursday), Newcastle District—Visits to works and power station.

July 6 (Friday)—Leave Newcastle for Leeds. Visits to works and excursions in the neighbourhood of Leeds.

July 7 (Saturday)—Leave Leeds for London.

Entertainment will be provided in London and local centers for the ladies of the party and those of their friends who desire to accompany them.

Electrolysis With Alternating Current

Editor, The Electrical Age:

Dear Sir:—

Referring to the remark made by F. J. Sprague in the discussion of a paper by B. G. Lamme on "Alternating Current Electric Systems for Heavy Railway Service" that "there is good reason for believing that electrolysis will take place," there is no doubt but he is quite correct, as this question has been carefully examined by experienced engineers, both in this country and in Europe. Experiments specifying every detail with different frequencies and under different conditions have been recorded, of which two only may be mentioned in this limited space.

The Proceedings of the Institute of Civil Engineers, London, of 1902 and 1903 contain records of several such experiments,—one by Philip Dawson (Vol. 149, page 96, 1902) may be sufficient as an example, as all the others are of the same character. He says:—

"His experience, with the fairly low frequencies which must be adopted for traction with alternating currents, was that the electrolytic action was nearly as bad as with continuous currents; the difference was that with continuous currents the resulting damage was limited to an area which could be predetermined, and safeguarded by means of additional return cables or negative boosters; whereas with alternating currents the area was not limited, and the damage was likely to be caused over the whole system."

Extracts from a more recent contribution by H. W. Fischer, of Pittsburg, Pa., referring to such action upon the lead covering of telephone cables, recorded in the proceedings of the Pittsburg branch of the American Institute of Electrical Engineers of December 12, 1905, are as follows:—

"The advent of the single-phase alternating-current railway system with grounded return brings up the question of electrolysis with alternating currents, and I have been making some experiments to determine whether under any conditions the lead covers of cables may be destroyed by alternating current. My experiments so far have not been very comprehensive, but I have found that under certain conditions destructive electrolytic action may occur with alternating currents operating at a frequency of 60 cycles per second.

"The solution I employed for the electrolyte was water containing common salt and salammoniac, all of which may occur in and around duct systems. I found that with a current density of 0.1 ampere per square inch of lead, there was no electrolytic action.

"With 3.04 amperes per square inch of surface, the amount of lead destroyed per ampere per hour per square inch was 0.004 gramme.

"With 11.8 amperes per square inch, the amount of lead destroyed per ampere per hour per square inch was 0.136 gramme.

"With 17.9 amperes per square inch, the amount of lead destroyed per ampere hour per square inch was 0.237 gramme. In this last case, a large hole was eaten through the lead and the surface exposed to electrolytic action was nearly a square inch.

"These tests were made in a practical manner without any attempt at great accuracy. The results show very plainly, however, that if the current density per square inch of surface is sufficiently great, destructive electrolytic action may take place with alternating currents. * * *

"The cable companies cannot guarantee their cables against electrolysis from alternating currents. * * *

"With a frequency of 25 cycles per second, the alternating current action would probably be greater than shown by my tests."

This question has, therefore, been pretty thoroughly investigated in this country and abroad in both laboratory and practical experiments, and seems to be well established at the present time. There may, however, be peculiarities, yet undiscovered, in the action of alternating currents on underground metals which will make it difficult to locate points of damage during a survey.

Very truly yours,

A. A. Knudson.

Wireless Telegraphy in China

Writing under recent date from Tientsin, United States Consul-General Ragsdale says that the Chinese Government has arranged to establish several stations throughout China for experiment with Marconi's system of wireless telegraphy and instruct Chinese operators in working it. The apparatus has been installed on four Chinese men-of-war at Shanghai and at the three North China cities of Tientsin, Peking, and Paotingfu, the radius of action being about 145 miles.

An Italian officer has been appointed, not only as instructor, but also as engineer to superintend the installation, and under him a number of students have already been detailed to act as operators and learn the art of management. It is also said that the viceroys throughout the Empire have been directed to consider the advisability of establishing other stations to work in conjunction with those mentioned.

In discussing the artificial lighting of works recently before the Coventry Engineering Society, A. E. A. Edwards said that machines should be painted a light colour, such as gray. In a case which came under his notice, the change in colour of machinery from dark to light gray had a marked effect on the shop's illumination.

Speed Regulation of Water-Power Plants

By JOHN STURGESS

From a Paper Read at the Recent Chattanooga Meeting of the American Society of Mechanical Engineers

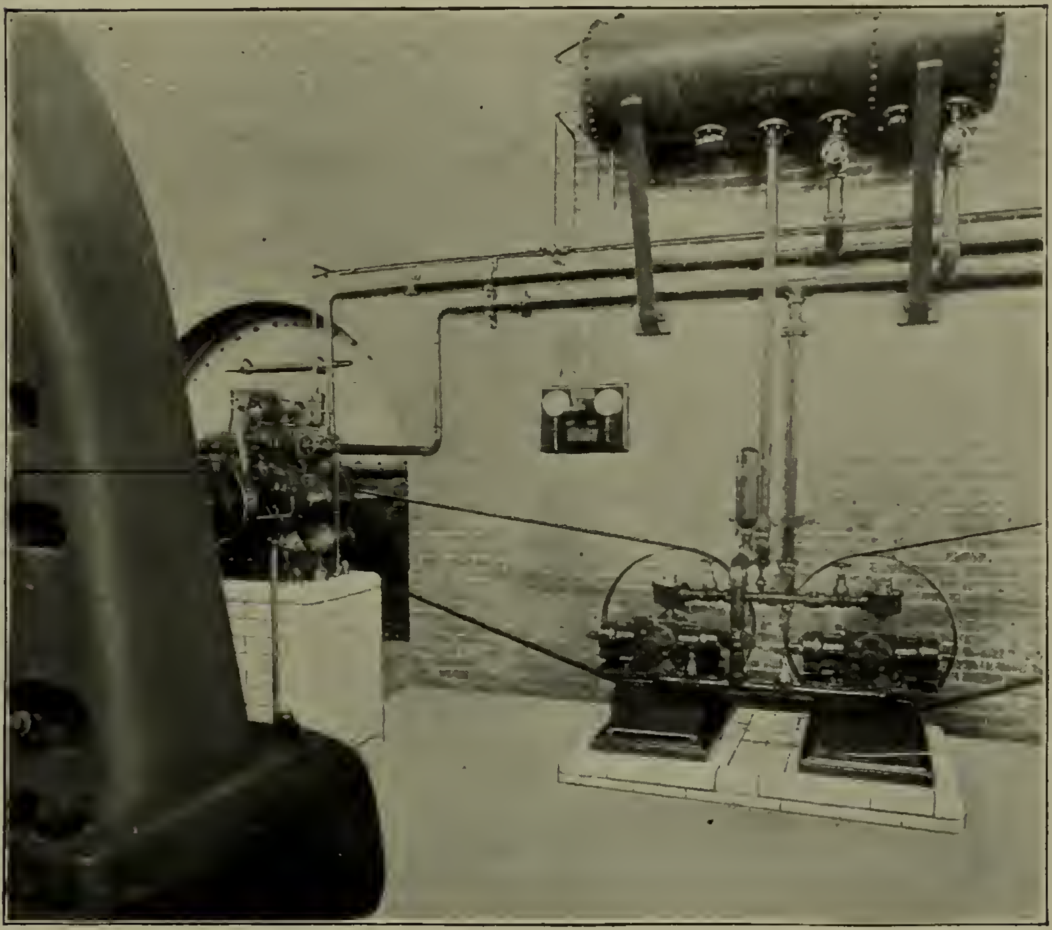


FIG. I.—PART OF A WATER-POWER PLANT, SHOWING GOVERNOR, STORAGE TANK AND BELT-DRIVEN OIL PUMPS, BUILT BY THE STURGESS GOVERNOR ENGINEERING COMPANY, WEST TROY, N. Y.

THE commercial importance of satisfactorily regulating the speed of water-power plants is now fairly well recognized, though it is surprising how often, even at the present day, the whole question of governing is treated as a matter of minor importance when the designs of the plant are in course of preparation. It has frequently occurred within the author's experience that the generators and water-wheels of a plant will be completed and installed before attention is turned to the governors. The consequence is that the latter unavoidably wear the aspect of a patch, are needlessly complicated and inconvenient, and are unnecessarily expensive, both to construct and maintain.

In regulating a water-wheel it is not sufficient to confine our attention to the governor only, for the problem is intimately associated with other important features of the plant. To gain a clear conception of this matter, we will divide the plant into the following elements:—

1. A great body of moving water, either completely confined in pipes or partially confined in more or less open channels.

2. A turbine wheel so set that all the water passing through the pipes or channels must pass through the wheel.

3. A gate, usually set immediately before the wheel, for controlling the power output of the wheel.

4. A governor for automatically operating this gate so as to maintain uniform speed on the wheel shaft.

The ultimate function of the gate is to control the power output of the wheel. It does so, or attempts to, by varying the aperture through which the water flows. It may appear at first sight that this means would directly accomplish the purpose, but a little consideration will show that it will not do so in the manner required under modern conditions.

The gate consists, essentially, of an adjustable aperture, as already stated. It is set so that the water passes immediately from the aperture into the wheel, this remark applying alike to cylinder, register, wicket and other forms of gates as found on water-wheels of the present day. Reducing the aperture by closing the gates is intended to reduce the power output of the wheel, and increasing the aperture by opening the gate is intended to increase the power output.

It will, however, be obvious that simply increasing or decreasing the aperture will not cause the power developed by the wheel to vary in like manner, for the reason that any sudden restriction in the aperture cannot instantly check the velocity of the mass of moving water extending throughout the whole hydraulic system. The immediate effect of reducing the aperture is to cause the same mass of water to be ejected on the wheel, but with a higher velocity, thus actually increasing the power of the wheel at the very moment when uniformity of speed demands that it should be decreased. On suddenly increasing the aperture, the reverse effect takes place.

It makes little difference if open channels are substituted for a closed pipe, except that certain danger elements are absent and an open channel usually has a larger cross-section, resulting beneficially in lower velocity of water, for the water will rise or fall at the forward end under similar circumstances and produce similar results at the wheel.

Close regulation requires an exact balance, at every instant, between the power output and the load. Any lack of balance in this respect will produce an immediate effect in the speed, unless the energy of the revolving mass is considerable, compared to the energy in output per second. As a 1000-horse-power wheel develops 550,000 foot-pounds of energy per second, if the gate is un-

able to control the power output closer than within, say, one second of the instant that the gate is adjusted, the wheel must inevitably be accelerated or retarded an amount equivalent to this amount of energy.

What the actual degree of this variation will be, will depend upon the momentum, or, more strictly, upon the kinetic energy of the mass to which the energy is applied, according to well-known laws. Unless this mass is very large,—much larger than is usually found in practice,—the speed variation from this cause alone will exceed the limits within which it is desirable to keep.

In plants where the pipe line is long and the velocity of the water high, the gates cannot control the power output of the wheel within several seconds of the instant that the gate is moved. When the energy of the revolving parts is low, as it frequently is, consisting of nothing but the momentum of a light water-wheel and a comparatively light revolving field or armature, no amount of perfection in a governor can prevent considerable momentary variations in speed when large changes of load occur suddenly. For it is to be observed that the causes of this variation lie quite outside the governor itself, as the variation would occur if the governor was instantaneous in its operation, and absolutely synchronous with the load change,—conditions which can only be approximated in practice.

It has already been stated that the act of varying the aperture through which the water passed not only failed to immediately control the volume, but actually produced a velocity in the water the reverse to that required, resulting in increasing the power output when a decrease was aimed at, and vice versa. This comes about because the gate is placed immediately before the water-wheel, which takes up the energy of the stream. Attempts have been made to obviate this by placing the regulating gate elsewhere than immediately in front of the water-wheel, though such arrangements have never come into general use.

One such attempt placed the regulating gate in the draught tube, a valve of the butterfly form being used. This is quite an old idea, though some recent wheels have been equipped in this manner in one of the Niagara Falls plants. Although it minimizes the deleterious effects previously referred to, this arrangement brings with it its own troubles, the principal disadvantage being that the relation between angular movements of the butterfly valve and the power output of the wheel follows a very erratic curve, making the regulation of such a wheel by an automatic governor an extremely difficult matter.

The wheels at Niagara Falls fitted with this system were provided with governors, but they were not operating when the author viewed the plant. Another attempt, tried at Shawinigan Falls, utilized an ordinary gate valve in the pen-stock, this gate being connected to an especially powerful governor. The author has no information as to the success of this arrangement, but doubts its feasibility.

When the pipe-lines are long, the use of relief valves or stand pipes mitigates the difficulty in some degree, and also removes the danger to the pipe-line which would occur by a too sudden closing of the gate. A relief valve takes care of only one-half of the difficulty, for while it will check in a large measure the increased pressure due to closing the gate, it is powerless to avoid the decreased pressure due to an opening movement of the gate. A stand pipe is partially effective in both directions, if large enough, but only in a limited degree. When stand pipes and relief valves are provided, it is usually more on the score of safety than for regulation requirements.

The best forms of relief valves are undoubtedly those which do not depend on a rise of pressure to set them in action, but which are mechanically opened synchronously with the closing movement of the gate, afterwards gradually closing automatically. By properly proportioning the discharge of such a valve to the discharge of the water-wheel, the gate can be closed very quickly without producing an appreciable rise in pressure.

A plant at St. Catherines, Canada, equipped with such relief valves (made by Voith, of Germany), and having pipe-lines several hundred feet long, the head being 298 feet, has been found to give remarkably good results when suddenly throwing off large amounts of power. The exact figures are not obtainable, but the author was told on good authority that the maximum momentary rise in speed on throwing off 75 per cent. of the full load was

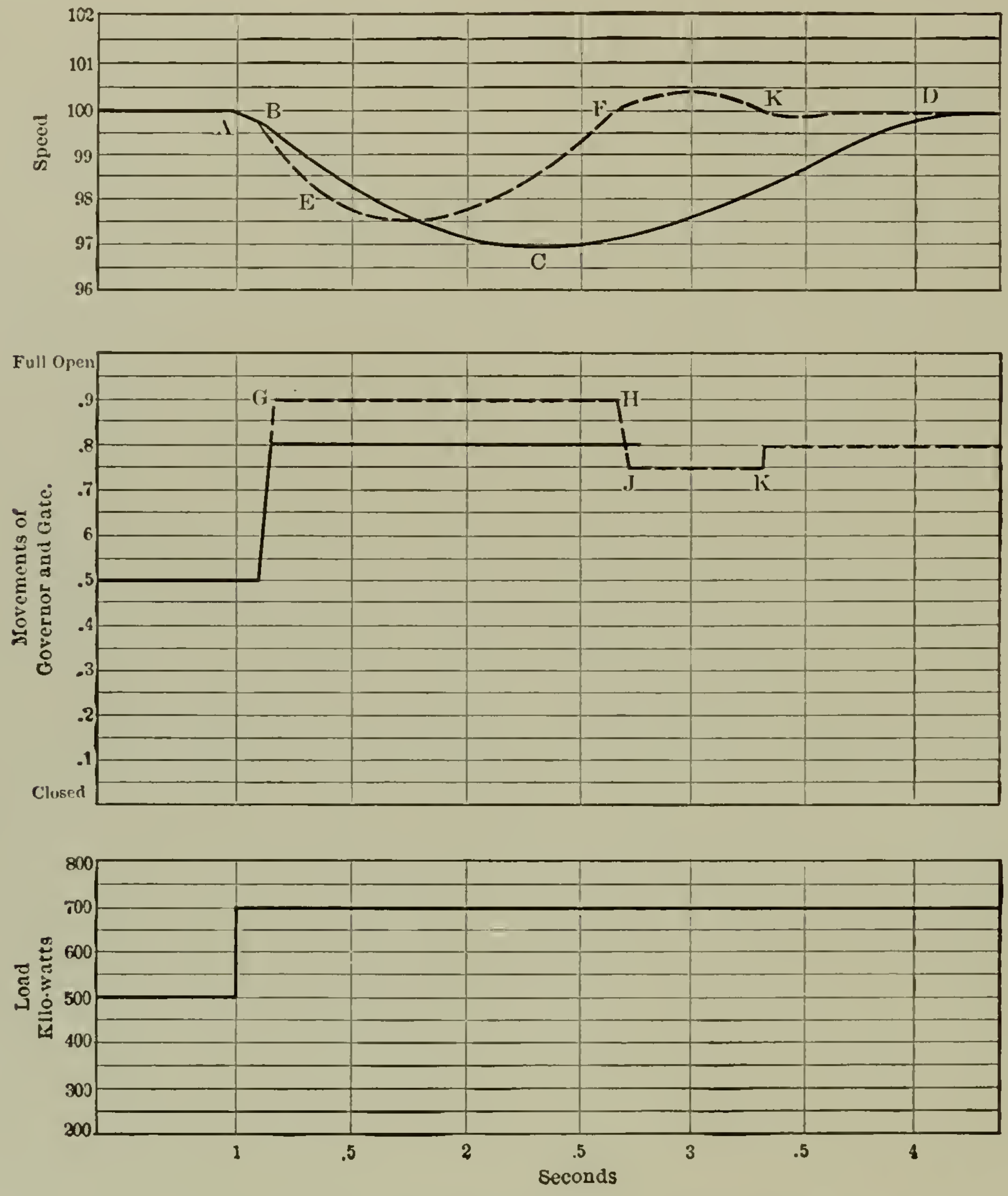


FIG. 2.—DIAGRAM SHOWING IDEAL RELATIONS BETWEEN SPEED, GOVERNOR MOVEMENTS AND LOAD CHANGE UNDER EXISTING CONDITIONS

under 4 per cent., an extremely good figure for such a plant. The units are of 7000 horse-power, revolving at a high speed, and having a large momentum factor.

From what has been said, it will be apparent that one of the obstacles to further improvement in speed regulation is inherent in the accepted designs of gates which are unable to entirely discharge the functions for which they are intended. Commercial reasons, however, and the existing organizations of manufacturers, render it unlikely that any great departure in principle of gate construction will be made in the near future, though there is no question but that considerable improvement is valve hydraulically controls a larger valve, which is too heavy to be moved by the centrifugal governor direct, and this in turn controls a piston in a hydraulic cylinder, the piston being connected by suitable mechanical means to the gate of the water-wheel. The parts are so related that, if the balls collapse below their mid-position, the piston will open the gate, and if they extend beyond their mid-position, the piston will close the gate.

The governor contains also another important element,—the compensator,—the functions of which will be realized when it is borne in mind that the speed of the wheel is not restored, after its initial deflection,

In America, the manufacture of water-wheels and of governors has been carried on, in the great majority of cases, as separate businesses, and on account of the great diversity of designs of water-wheels and their gate rigging, the governor manufacturer has perforce been obliged to adopt a design which is applicable to all designs of water-wheels. This, for commercial reasons, necessitates the governor being self-contained and independent of the wheel, and usually results in an unavoidable complication in the connections between the hydraulic piston and the gate.

From an engineering standpoint, the European practice is to be pre-

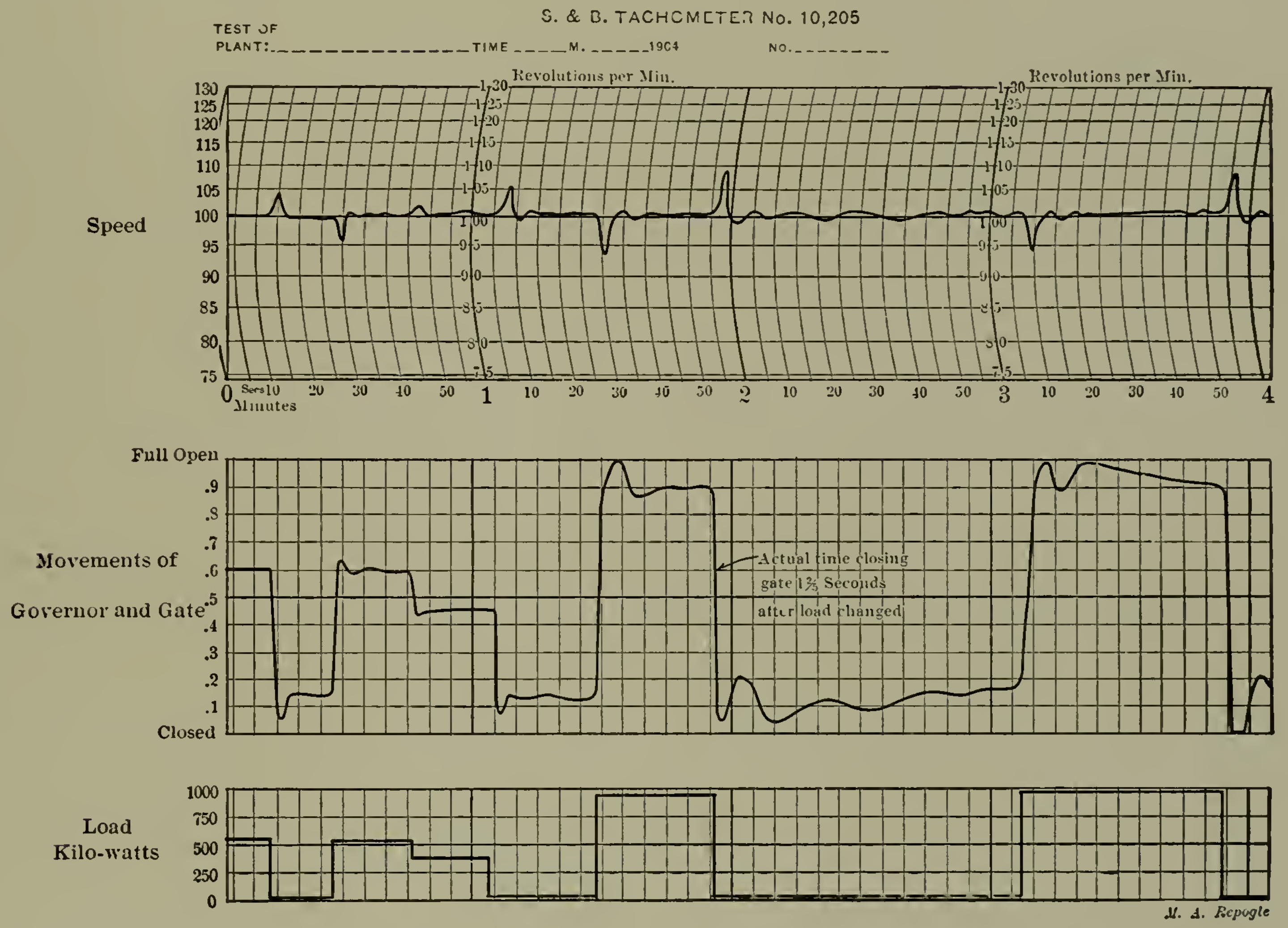


FIG. 3.—CURVES, REPRODUCED FROM TESTS, SHOWING RELATION BETWEEN SPEED, GOVERNOR MOVEMENTS AND LOAD CHANGE, WITH HEAVY SUDDEN CHANGE OF LOAD

desirable, not only for the reasons given, but because water-wheel gates as now designed are poorly working apparatus at best, however well constructed.

We now have to pass to the consideration of the governor itself. The limits of this paper preclude more than a brief reference to its essential features and an examination of certain of the characteristics of its operation.

The most successful governors are of the hydraulic class. They consist of a centrifugal governor belted from the water-wheel and adapted to move a small piston valve. This until an appreciable interval after the gate has been moved. This interval would be sufficient for the governor to move the gate to its full open, or closed position, and violent racing would result. The compensator checks this by causing the governor piston to move an amount proportional to the degree of the initial speed variation. This is accomplished by making the movement of the governor piston react on the centrifugal governor, or its connections, so as to virtually reverse the movement which was initially produced by the changed speed, induced by the changed load.

ferred where the wheel and governor are incorporated in one design. The hydraulic piston is directly connected to the gate, thus avoiding the rotary shafts and geared connections necessary with the separate governor. In this country, however, with its tendency to specialize, the greatest success, both commercially and technically, has been secured when the water-wheels and the governors are made by separate manufacturers who are specialists in this line.

Some of the water-wheel manufacturers have attempted building their own governors, but they have usually abandoned their efforts for

the reason which is here given.

In order to secure good regulation it is necessary, first, that the smallest departure of the speed from normal shall cause the hydraulic piston to operate, and, secondly, that it shall operate with extreme quickness. Even if after full load has been thrown off, the governor occupies one second in closing the gates, a considerable excess of energy will be produced (amounting to over half a million foot-pounds in a 1000-horse-power wheel) which will cause a considerable acceleration unless the momentum of the revolving elements is very large.

In many cases it is not even practical to close a gate as quickly as this for mechanical reasons; and having arrived at a practical limit in this respect, the only possible way of preventing considerable momentary fluctuations when large changes of load occur, is by making the momentum of the revolving element sufficiently great to take care of the excess energy. This point is very rarely considered by the designers of water-power plants.

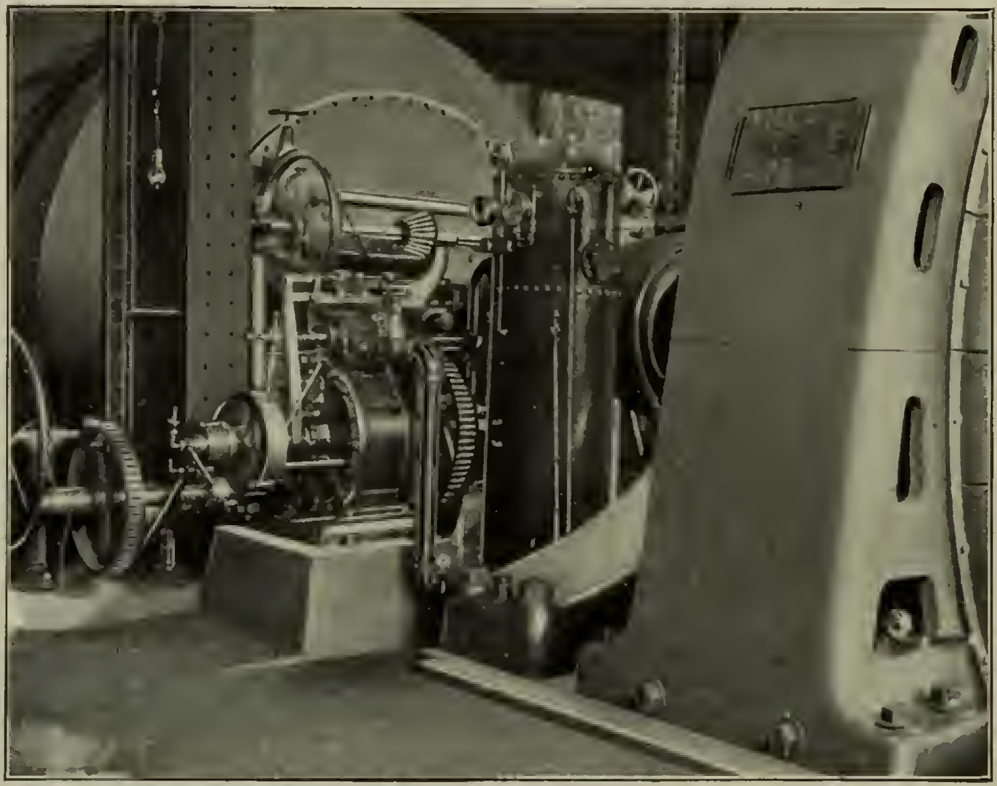


FIG. 4.—ONE OF THE 20-FOOT-TON STURGESS GOVERNORS USED IN THE 30,000-HORSE-POWER PLANT OF THE HUDSON RIVER ELECTRIC COMPANY, SPIER'S FALLS, N. Y.

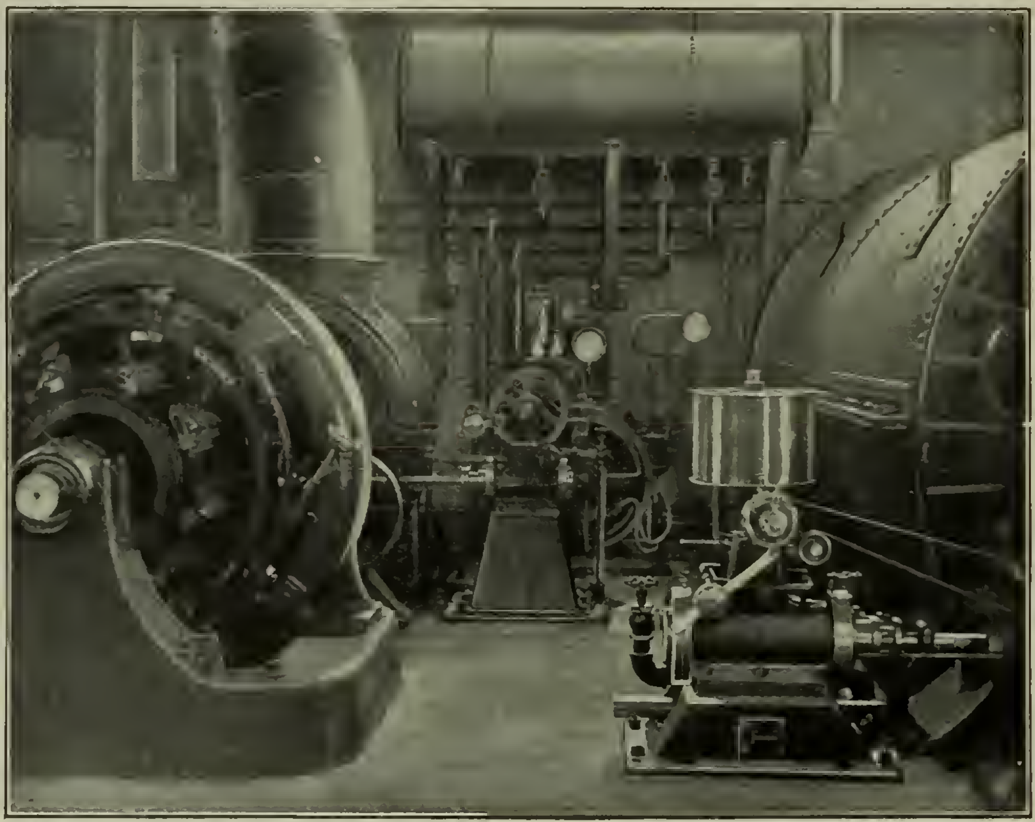


FIG. 5.—IN THE 12,000-HORSE-POWER PLANT OF THE HURONIAN COMPANY, CAN., THE HYDRAULIC GOVERNORS ARE OPERATED BY A CENTRAL PRESSURE SYSTEM SUPPLIED BY DUPLICATE MOTOR-DRIVEN OIL PUMPS

During some tests conducted by the author on a 1100-horse-power unit, on throwing off the full load, the five gates were completely closed in 1 2-5 seconds,—an extremely quick performance when it is borne in mind that 96 leaves in the five gates had to be moved a considerable distance through moving water, in addition to the mechanism for operating them, the moving parts of the governor and the heavy connections between governor and gate shaft, as well as a counterweight, weighing nearly one ton. Even under these circumstances the wheels and the revolving field of the alternator, weighing several tons, accelerated over 70 per cent. in this short interval, the speed rising from 120 to 129. This was due partly to the energy developed by the wheel during 1 2-5 seconds while the gates were closing, and partly to the inertia effects of the water referred to in the former part of this paper.

On watching the forebay while the experiment was repeated, the water was seen to rise several feet, and a great turmoil took place, though the channels were capacious and short. The effect on the wheel was, of course, violent fluctuations in effective head. The speed was maintained fairly uniform, though the governor necessarily continued moving the gate as the head fluctuated, producing, at first sight, the appearance of racing.

A similar test conducted at another plant where the head race was several hundred feet long, and partially closed at both ends by the head gates and intake, resulted in the formation of a long, low wave which continued to travel back and forth in the channel for a great length of time, creating at the wheel a rythmic rise and fall of head of about 20 per cent., having a period of several minutes. The governor responded by slowly opening and closing the gates as the head fell and rose, and at first sight this was thought to be racing (a slow form peculiar to water-wheel regulation) as the load was uniform.

The diagram, Fig. 2, indicates, in general character, the greatest perfection that can be obtained with any governor under prevailing conditions. The upper curve indicates the speed, the middle curve shows the movements of the governor and gate, and the lower curve the load.

Following these curves simultaneously, we note that at the start the speed is normal, the gate half open, and the load 500 kilowatts. At the

moment indicated by 1 second, the load is suddenly increased to 700 kilowatts. As a first effect the speed immediately begins to fall, following the line *A-B*. After the fall has reached, say, 0.1 per cent., the governor is thrown into action, and the gate is suddenly opened to 0.8 gate.

For reasons that have been already outlined, this opening movement of the gate will not cause the wheel to instantly increase its power. Therefore, the speed will continue to drop, following the curve *B-C*. As the water column accelerates, the power of the wheel will increase and the speed rise, following the curve *C-D*, being finally restored to normal, providing the gate was moved the right amount.

It is to be noted that, with the exception of the slight drop in speed, *A* to *B*, which took place before the governor moved the gate, say, 0.1 per cent., and the consequent delay in moving the gate after the load changed, the subsequent drop in speed is due to causes quite outside the governor itself.

In some cases, however, by adopting an expedient, an improvement can be effected. Thus, if instead of stopping at 0.8 gate, the amount actually necessary, the governor had continued opening the gate to 0.9, as shown by the dotted lines *G-H* on the diagram, the acceleration of the water column would have been augmented, the speed following the curve *B-E-F*. The gate being too far open, however, the speed will rise above normal, but at this moment the governor will make a quick reverse movement *H-J*, turning the speed curve downwards *F-K*. A third similar movement may take place later. The dotted curve is an obvious improvement over the full-line curve.

The curves in Fig. 3 show some tests made by the author on a 1100-kilowatt unit. The curves were traced by a special Schaffer and Budenberg tachometer, the readings being sufficiently magnified to bring out the characteristics of the governor. The reverse curves, similar to the dotted curve on Fig. 2, are clearly seen. The load changes and governor movements are plotted below. Note that when the whole load was thrown off,—at 1 minute, 55 seconds,—the speed accelerated about 8 per cent. in an incredibly short time,—under 1 second.

The governor had the gate shut in 1.4 seconds after the load went off, and its subsequent behavior, as shown by the middle curve, was interesting, in view of what has been said before. It is to be noted that after the first quick reverse at 2 minutes, the governor slowly oscillated for about another minute, but with a gradually increasing gate opening, the speed and load being

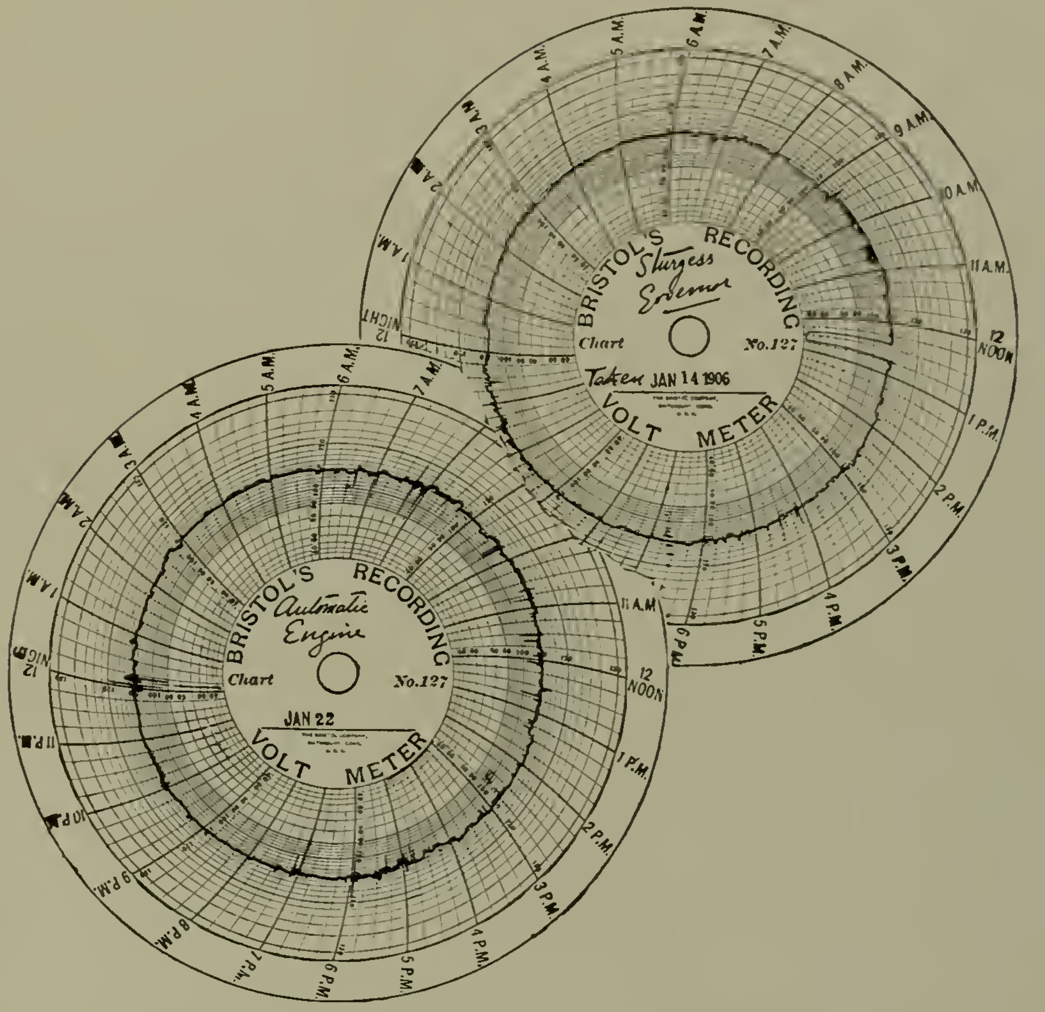


FIG. 6.—VOLTAGE RECORDS, SHOWING COMPARISON BETWEEN REGULATION SECURED BY STEAM ENGINE AND WATER-WHEEL GOVERNOR

practically constant. This was due to the water rising in the forebay and gradually subsiding in a succession of waves, the governor taking care of these fluctuations in effective head in a very intelligent manner. A similar effect is shown at 3 minutes 10 seconds, when the load was thrown off.

A comparison of the regulation, as gathered from a voltage record, of a water-wheel and a steam engine is shown by the Bristol records in Fig. 6. The engine is of the Ball & Wood type, having an automatic cut-off controlled by a good inertia-centrifugal governor. For all practical purposes the records are equal. The load was principally induction motors of various sizes. These curves are not offered as the best examples of speed regulation that can be obtained, but as showing the characteristics of water-wheel governing. It is quite possible to get charts which simply show a straight uniform speed line, such as Fig. 7, but nothing is to be learned from these, unless the load conditions are known.

When attempting to forecast the degree of regulation obtainable in a given plant, we find that one of the most important items, that is, the maximum momentary variation which will occur when making given changes in load, is practically uncalculable. An equation can be devised for ascertaining this, but solving it calls for data which have not yet been procurable. Under the circumstances, all we can do is to compare the plant with others of similar

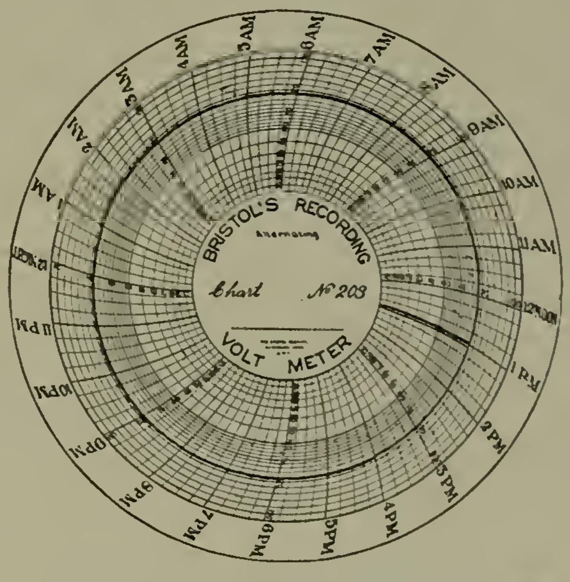


FIG. 7.—VOLTAGE RECORD OBTAINED FROM WATER-WHEEL

design, on which accurate tests have been made, and make our forecast accordingly.

We can, however, forecast with precision the following conditions,

and if these are realized, and the plant properly laid out, very good regulation will be obtained under ordinary conditions of operation:—

1. The governor shall apply to the gates a definite amount of energy.

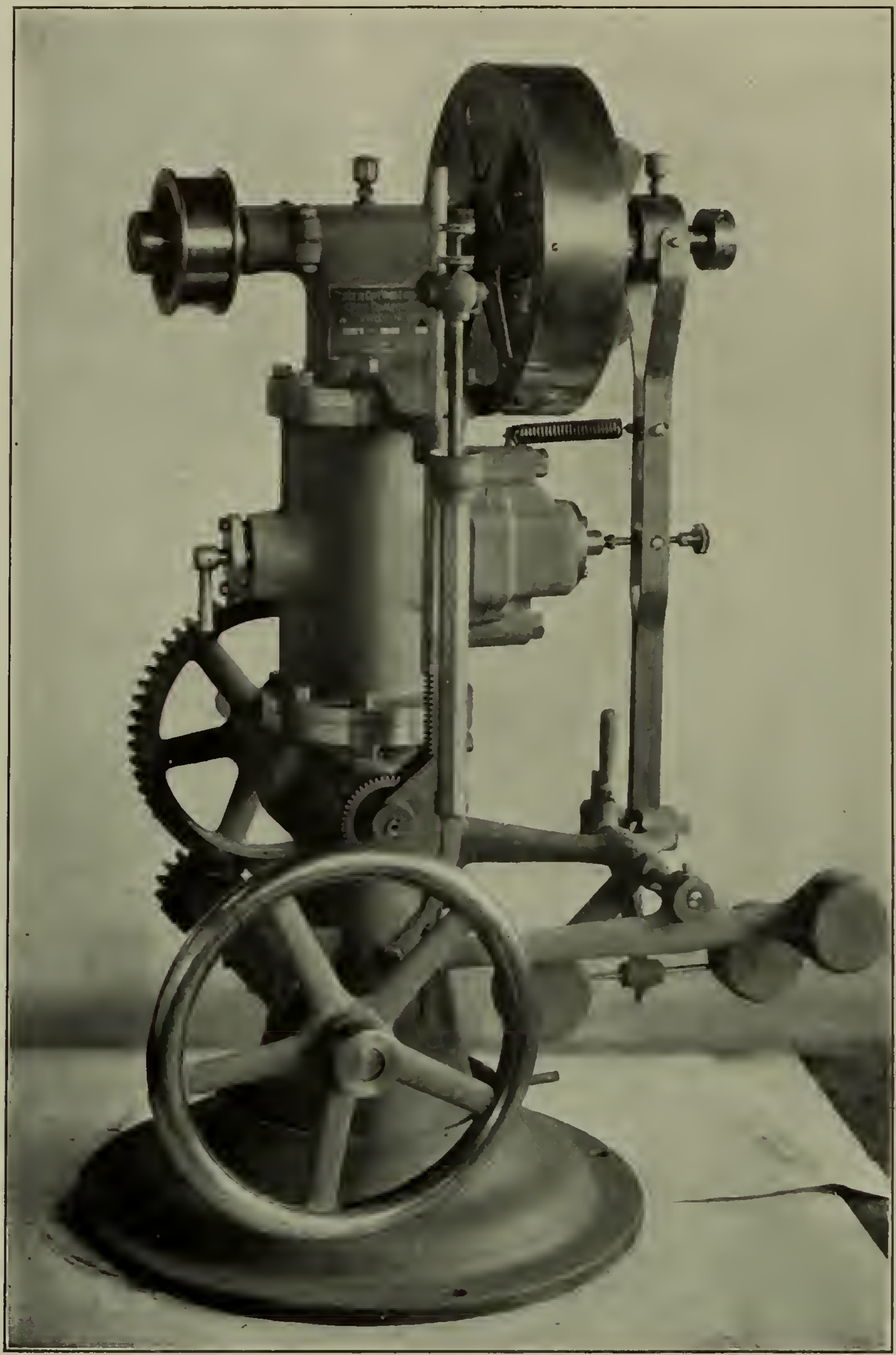


FIG. 8.—VERTICAL FORM OF STURGESS WATER-WHEEL GOVERNOR

2. It shall operate on the speed varying ½ per cent. from normal.

3. On a considerable change of load taking place it shall promptly move the gates to the position required by the changed load.

4. It shall move the gates through their full range in 1½ seconds.

5. Under steady head and steady load it shall remain stationary, and it shall not make more than three movements in re-adjusting the gate after any change of load.

The necessity for the first clause, instead of a definite statement that it shall move the gate, arises from the fact that the amount of energy required to move a gate is a very uncertain quantity, for which no one seems to be held responsible. A 5000-horse-power wheel may require from 15 to 20 foot-tons to move the gate. One such wheel with a flanged gate operating under 78 feet head required 34 foot-tons when it was in good condition and $34 \times x$ when it was in bad condition, x being entirely indeterminate, as it was caused by the water-wheel resting in the gate and raising ridges in the metal, which effectually prevented the gate being moved one way or the other.

The general arrangement of the governors on the 5000-horse-power wheels of the Hudson River Electric Company's plant at Spier Falls, N. Y., is shown in Fig. 4. The governor shaft is connected to the gate mechanism of the water-wheel by a cable drive. The storage tank, holding the oil under pressure, is seen immediately behind the governor, the pump which maintains the pressure being placed on the opposite side of the wheel shaft. Other arrangements are shown in Figs. 1 and 5, where one large tank was used to supply the governors, either a number of belt-driven pumps, or one motor-driven pump being used to maintain the oil in the pressure tank.

A later design of governor is shown in Fig. 8. The reciprocating piston rotates the governor shaft by means of a rack and pinion concealed within the pedestal of the governor, forming practically an extension of the cylinder. An important feature in this machine, not shown, however, is the arrangement of conical-lift valves to give admission to the cylinder. These replace the piston valve which has hitherto been used exclusively.

Prize for a Current-Limiting Device

A PRIZE of $500 is offered by the Hydraulic Power Syndicate, of Grenoble, France, for a current-limiting device. On the system of wiring which distributes current to the subscribers of this system, each of the branch circuits is established so as to provide for a certain power whose maximum is determined in advance, and the arrangement is made with the subscriber either by contract or meter. It often happens that the maximum of current is exceeded for more or less time, and this causes trouble upon the whole system which the station supplies. They wish to adopt a method which will allow of notifying the subscriber in the first place, and if he pays no attention, of obliging him to return to the conditions of his contract, this without annoying surveillance on the part of the central station. The proposed current-limitating device must work at a higher power than 5000 watts and on all kinds of current. It must give a signal as long as possible before it commences to operate; then it must limit automatically the current on the branch line, working every time the proper current is exceeded, so that if set back again, it will leave each time an indication of the resetting.

It is reported that a wireless telegraph station will be installed at the new Hotel Belmont, in New York.

A High-Tension, Direct-Current Testing Set

By Dr. CLAYTON H. SHARP, Test Officer of the Electrical Testing Laboratories, New York

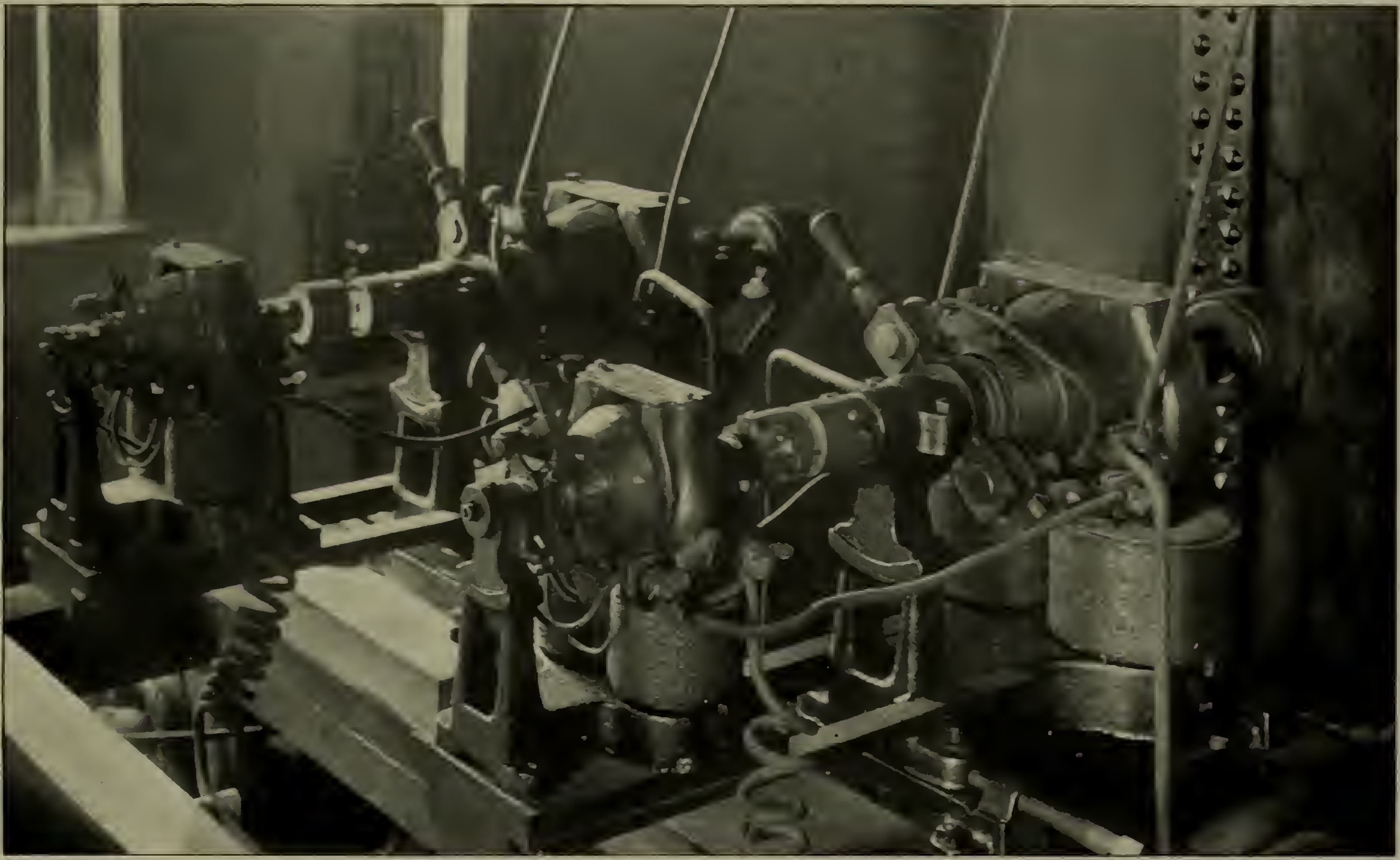


FIG. 1.—A PART OF THE HIGH-TENSION, DIRECT-CURRENT TESTING SET BUILT BY THE CROCKER-WHEELER COMPANY, OF AMPERE, N. J., FOR THE ELECTRICAL TESTING LABORATORIES IN NEW YORK. EACH GENERATOR DELIVERS 0.2 AMPERE AT 2000 VOLTS. FIVE ARE CONNECTED IN SERIES, SO THAT 10,000 VOLTS ARE AVAILABLE

FOR certain lines of laboratory testing or experimenting, it is necessary or desirable to have at command a high-tension, direct-current supply. For instance, a high continuous tension is useful in determining the resistance of materials of high insulating power; in investigating the properties of dielectrics under conditions precluding dielectric hysteresis, since it is known that some substances are much stronger under continuous tensions than under alternating ones; in studying the discharge through gases, vapors, etc.

This high-tension may be furnished either by a multitude of voltaic cells, preferably small storage cells, or by one or more dynamos. The care and labour in the maintenance of a sufficient number of cells to furnish say, 10,000 volts is so great as practically to preclude their use, except in very special cases. On the other hand, it has been demonstrated that a voltage as high as this may very readily be obtained from generators of small size connected in series.

The first high-tension direct-current testing plant of this sort was installed at Cornell University, and has been described by Professor Moler. In this plant about twenty-four Crocker-Wheeler generators of 500 volts each are connected in series. For the purpose of diminishing electrical stresses on the insulation of the machines, they are divided into three groups of eight machines each. All the machines of each group are excited in parallel from a separate exciter. As the maximum potential difference on a group does not exceed 4000 volts, this procedure is a safe one. To protect the dynamos from electrostatic effects, each is surrounded by a cage of wire netting. Good precautions are taken to secure the safety of the operators. This plant has been, so far as is known, satisfactory in its operation and has been reproduced as far as its essential features are concerned in a 10-unit, 5000-volt set at the National Bureau of Standards.*

On taking up the subject of a high-tension, direct-current plant for the Electrical Testing Laboratories, of New York, nearly three years ago, it was found that the Crocker-Wheeler Company, of Ampere, N. J., would agree to construct small generators delivering 0.2 ampere at 2000 volts each. In view of the increased simplicity resulting from the use of a smaller number of machines, it was decided to install this size. Five of these machines were ordered, together with a spare armature.

The higher voltage of the units

* Nutting, Bulletin of Bureau of Standards, Volume I., page 449, 1905.

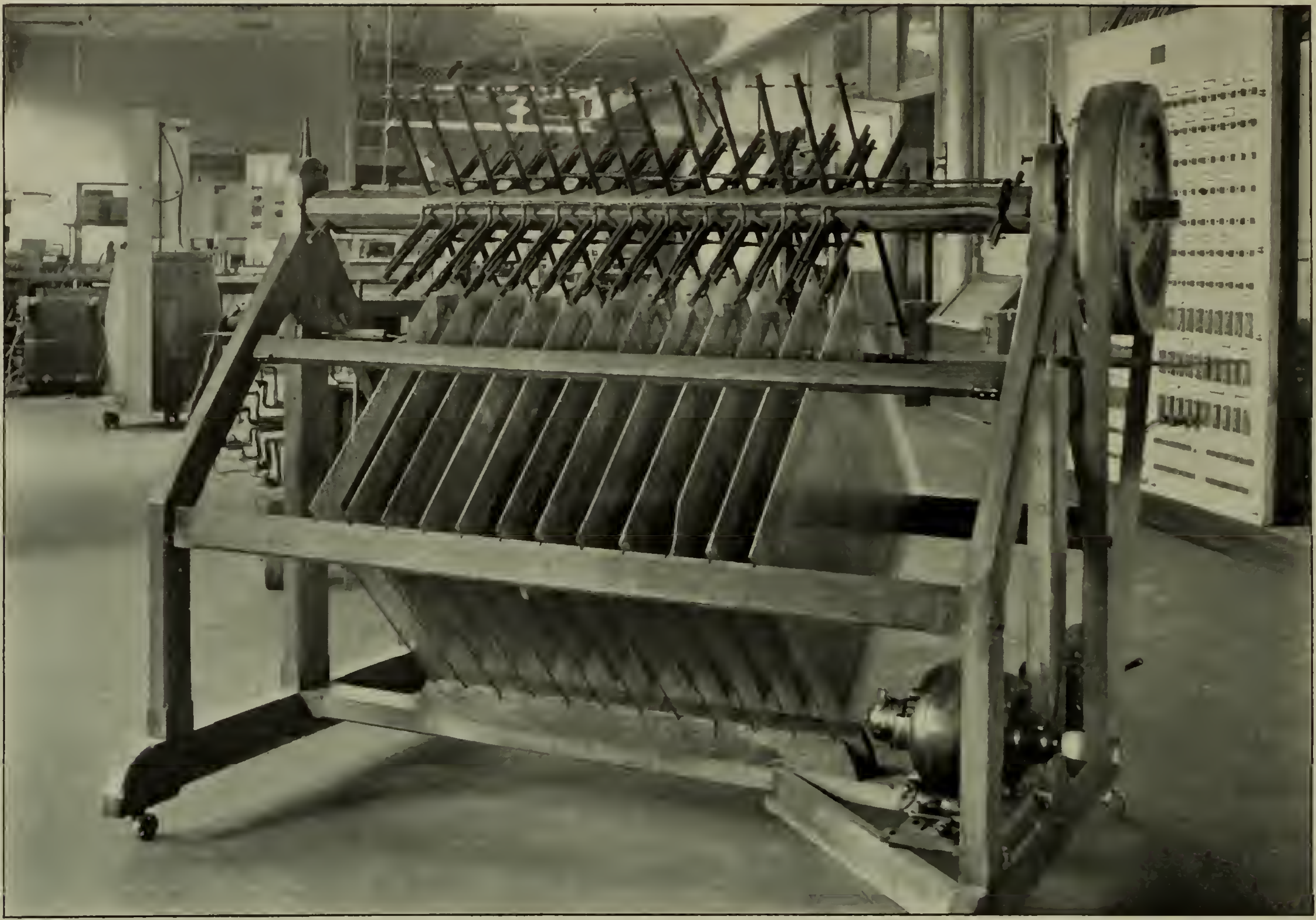


FIG. 2.—CONDENSERS USED IN CONNECTION WITH THE GENERATING SET. THEY ARE CONNECTED IN MULTIPLE FOR A 10,000-VOLT CHARGE, AND IN SERIES FOR A 120,000-VOLT DISCHARGE

made it necessary to adopt some scheme for excitation whereby the stresses on each generator would be kept within safe limits. The most feasible plan appeared to be to use a direct-connected exciter with each generator. These exciters are rated at 0.6 amperes, 125 volts, and are supported on angle irons, which are secured to the frame of the generator, and which carry wooden plates for the exciters.

The exciters are driven by couplings, consisting of split wooden discs attached to the shafts, and united by two metal pins, which are attached to one disc and fit loosely into holes in the other disc. Thus it will be seen that the exciter frame is insulated from the generator frame. The only electrical connection between the two is from the brushes of the exciter to the field of the generator.

A view of two of the units is given in Fig. 1. The machines are mounted on a stout wooden framework, two "stories" high, three of the sets being on the lower "story" and two, those shown in Fig. 1, on the upper. The motor which drives them is placed on an extension of the same framework. Each generator set is placed on an insulating slab of "alberene" stone, which forms its support.

Both ends of the motor shaft are equipped with driving pulleys. The two upper sets are driven from pulleys in one end, and the three lower sets from the other pulley. The pulleys on the generators are of paper, to insure good insulation from the belts. It has not been found necessary to make further provision against electrostatic effects. This arrangement is compact and convenient and has proved to be satisfactory, both from an electrical and mechanical point of view.

The generators are connected in series. Leads are brought from them to six terminals on a switchboard in a testing cabinet, so that any number of the machines can be used for a test, thereby providing a rough graduation of voltages into steps of approximately 2000 volts each. Beneath each terminal is a hook, which is brought into electrical contact with the terminals by a switch. In front of them runs a bar which can be connected to any hook by a rod with an insulating handle. This rod forms one terminal of the testing circuit. The series of switches is opened and closed automatically when the glass windows in the front of the cabinet are raised and lowered. When the windows are raised, giving access to the interior, the switches are opened and the testing circuit is disconnected. This constitutes a practical device for securing the safety of the operator.

The field rheostats of the generators are attached to the cabinet in such a way that only their wooden handles are accessible. The regulation of the voltage is secured by means of these rheostats and also by varying the speed of the motor driving the generators, a rheostat for motor control being also affixed to the front of the cabinet. The voltage can be brought with sufficient nicety to any value up to the maximum potential of the set, which has been found actually to be about 12,000 volts. When generating their maximum voltage, the machines run with very little sparking.

In some classes of testing it is desirable to be able to apply a high

voltage suddenly to the object under test. This may be accomplished by connecting the test object to a charged condenser or series of condensers. Lightning arresters may very well be subjected to such a test. An apparatus for this kind of work has been constructed for use in connection with the high-tension, direct-current set, and, while it presents no novelties in principle, yet may merit description on account of simple construction and satisfactory operation.

The apparatus, a view of which is given in Fig. 2, consists essentially in a framework, carrying twelve glass-plate condensers and a rotating commutator, by which the condensers are connected in multiple for charge from the 10,000-volt direct-current set and in series for discharge at 120,000 volts. The framework is of dried ash, substantially joined and mounted on casters, so that it is easily movable. The condenser plates are 24 inches square, and are covered with tin foil, to within two and one-half inches of the edges. The tin foil was cemented by means of shellac and the plates were coated with shellac after the tin foil had been attached. The squares of glass are placed with one diagonal vertical, and to the upper corner of the tin foil are cemented little copper buttons, to collect or discharge the electricity to the brushes.

The portions of the hardwood frame with which the glass plates come into immediate contact were thoroughly dried by artificial heat and treated with hot oil, in which a considerable amount of paraffine was melted. This procedure secured the necessary insulation between plates. The commutator consists of a long shaft of hard wood, well dried, running in bearings and fitted with wooden pins carrying the contact brushes. The shaft was treated with hot oil and paraffine. The pins, which were made of dowel material, were thoroughly dried and impregnated with hot paraffine. The insulation resistance of such material is enormously high.

Four sets of pins are used, two for charging and two for discharging. The space between the plates is so narrow—3 inches—that the charging brushes could not be put in line with each other without danger of sparking occuring between them. To obviate this difficulty, one pin was made shorter than the other, and an extra set of buttons placed on one side of the condenser plates. The brushes are of fine brass wire, cemented by means of sealing wax into bushings of glass tubing. The connections are made with high grade rubber-covered wire, fastened directly to the framework.

The discharging circuit consists simply of brushes long enough to extend from one plate to the next. The discharging terminals of the circuit are wires with buttons on the ends, and are carried in long glass tubes set into the end supports of the frame. The commutator is driven by a $\frac{1}{4}$-H. P. motor on the base of the frame. The principal dimensions of the apparatus are as follows:—

Framework, length	5 feet, 3 inches
Framework, width	3 feet, 7 inches
Size of plates	24 inches x 24 inches
Size of tinfoil coating	19 inches x 19 inches
Number of plates	12
Distance between plates	3 inches
Maximum radius of rotation of commutator	11 inches
Electrostatic capacity, plates in parallel	0.0783 microfarads

In operation, this apparatus yields a series of heavy discharges. the rapidity depending on the speed of rotation of the commutator. By coupling the commutator by a chain drive to the axis of a synchronous motor, or of a rotary converter, or of an alternating-current generator, the condensers might be charged from the peaks of the waves from a high-tension transformer. Thus the arrangement of the Thomson dynamostatic machine would be reproduced in principle. The availability of a high-tension, direct-current set makes it unnecessary to resort to this arrangement.

The apparatus has developed no signs of weakness, and is satisfactory in its behavior.

The Application of Electric Power to Gold Dredging

In discussing the use of electricity in the operation of gold dredges recently before the Colorado Electric Light, Power and Railway Association, J. F. Dostal said that from its nature, the dredge is not adapted to the receiving or carrying of fuel, often being operated at points very difficult of access; and by its great flexibility, electric power is the ideal motive-power for this class of service and has become universally used, making it possible to reduce the working force one-half.

There are at present two of these dredges being operated near Golden, Col., power being furnished from Denver. One is owned by the Clear Creek Dredging Co., about 12 miles from Denver, and the other by the National Gold Dredging Co., about 11 miles. It is reported that two more will be installed within the next year, but this cannot at present be verified.

The electrical equipment of one of these dredges is as follows:—One 20-H. P. three-phase induction motor for operating the revolving screen. One 20-H. P. induction motor for operating the shaking screen. One 20-H. P. induction motor for operating the stacker, or conveyor that deposits the gravel in the rear. One 30-H. P. induction motor for operating the sand pump. One 50-H. P. induction motor direct connected to 10-inch and 6-inch centrifugal pumps for furnishing water to the revolving and shaking screens. Two 45-H. P. direct-current motors with series-parallel-reverse control for operating the buckets. One 20-H. P. direct-current motor used to operate winches and in moving the boat and raising and lowering the anchor. One 10-H. P. induction motor for driving a centrifugal pump in the hold, used in priming the other pumps and for clearing the hold of leakage water.

The direct-current motors are supplied by a 100-KW. rotary converter. and a 5-KW. transformer (370 to 110 volts) supplies current for the lights when operating at night.

The entire electrical equipment was supplied by the General Electric Company. The induction motors start with a separate compensator and all operate at 370 volts, three-phase. The direct-current motors operate at 600 volts.

As to the nature of the loads on the various motors, that on the motors driving the buckets is a peculiar one. It may be described as a combination of an elevator and a street car load, with not quite as many stops and no particular need for very rapid acceleration. When beginning a cut at the surface, the incline up which the buckets travel may be only 20 degrees from the horizontal: the soil is as a rule very loose and the starting torque is, comparatively speaking, nominal.

The motor has only to overcome the inertia due to the mass and weight of the buckets, that is, from 400 to 600 pounds per foot of length. As the buckets become loaded with gravel the load increases. The speed of the buckets at the top of the cut may be as high as 50 feet per minute. This load is similar to

an elevator load and is steady, the only fluctuations being caused by a bucket, as it revolves around the lower tumbler, taking an extra large bite out of the gravel or else missing the gravel entirely.

As the depth of the cut increases the load becomes heavier, because of the great angle up which the buckets travel, the gravel being packed harder and because of the occurrence of large bolders.

Most of the gold is found in the gravel immediately over bed-rock, and it is desirable to get all of this gravel possible. The most severe condition on the motors occurs when they are stalled, caused by the buckets striking an extra large boulder, a stump, or by the bank caving and completely burying the buckets. In such a case the motors are reversed till a little slack is gotten into the chain; the motors are again started, and this reversing continued till the buckets are worked loose.

Whatever the nature of the obstruction is, it must be overcome, because the boulders, if not dug out, will form an effective barrier between the buckets and bed-rock, and upon bed-rock lies the biggest per cent. of the gold. On some of the newer dredges, variable speed induction motors are used for the buckets and winch drive, thus dispensing with the rotary converter.

Rotary converters, especially when operated on 60-cycles, are not entirely satisfactory and more or less trouble is encountered in their operation when handled by inexperienced men; and the experience of dredging engineers is that the reliability of the induction motor drive more than offsets the higher efficiency of the series-parallel control of the direct-current set. Actual tests on the bucket motors show them to operate at from 1.4 to 25 per cent. overload.

The induction motors driving the centrifugal pumps, shaking screen, revolving screen and conveyor are, after once started, subject to a constant load or very nearly so. Actual tests show them to be loaded as follows:—

50 H. P. for centrifugal pumps, 60 per cent. full load.

20 H. P. on conveyor, 35 per cent. full load.

20-H. P. revolving screen, 29 per cent. full load.

20-H. P. shaking screen, 34 per cent. full load.

10 H. P. for hold pump, 30 per cent. overload.

The motor that drives the winches is not subject to any unusual load. The power required to move the boat is not great and the winches are fitted with two-speed gearing and friction clutches; a good part of the time this motor is running light. Test shows this motor to operate at from 1.4 to 50 per cent. overload.

The load, from the central station standpoint, is a very desirable one. They operate the entire 24 hours for nine months of the year in this climate, and for the remaining three winter months it is a day load, just exactly the load the central station is looking for to improve its load factor.

As a matter of fact, the machinery is so heavy and the service so severe that they are shut down possibly 20 per cent. of the time for repairs. As a matter of general interest, it might be said that the bucket train consists of 40 buckets of $5\frac{1}{2}$ cu. ft. capacity, weighing 1500 lbs. each and capable of handling about 3000 cu. yds. of gravel per 24 hours.

The consumption for a dredge of this size is very nearly one KW.-H per cubic yard of gravel handled. Current is delivered on the grounds of the dredging company at approximately 11,000 volts, three-phase and 60-cycles; it is stepped down to 370 volts and delivered on board at this pressure.

The step-down transformer station is quite unique inasmuch as it is portable in form. The transformer house, containing three 50-KW. oil-cooled transformer choke coils, lightning arresters and switches, is built as compact as possible and mounted on skids, so that it may be moved from place to place as the operation of the dredge progresses. The dredge is connected to the transformer house by 600 feet of No. 000 three-conductor cable. This allows the dredge to operate over quite a large area and necessitates the moving of the transformer house only once in every four months.

Since the direct-current motors cannot be operated at potentials greater than 600 volts, this requires that the alternating current shall not be at a greater pressure than 370 volts; and as the induction motors must be built for this voltage they must all be special machines. This departure from the line of standard operation makes the installation more expensive and difficult to replace in case of accident. This is a strong point in favor of the induction motor drive on the buckets.

The waters of Lakes Lyddaw and Glaslyn, in Wales, are to be used to generate electric power for the Welsh slate quarrying industry. An effective head of 1100 feet is available.

Wireless Telegraphy in the United States Navy Department

At a recent meeting of the Washington Society of Engineers, the work of the Navy Department with wireless telegraphy was described by Lieutenant-Commander S. S. Robison.

The department now has about 35 land stations working, about 50 stations aboard ships, and plans are being made for still more. On the Atlantic Coast there are stations at Portland, Me.; Portsmouth, Boston, Cape Cod, Newport, Montauk, New York Navy Yard, Navesink, Annapolis, Washington, Cape Henry, Norfolk, Diamond Shoals Point, Charlestown, St. Augustine, Key West, Pensacola, Cuba, Porto Rico, New Orleans and Colon.

On the Pacific Coast there are stations at San Diego, near Santa Barbara, Farallone Islands, off the Golden Gate; Goat Island, in San Francisco Bay; Mare Island. Three or four others are to be built farther north. There is one at Honolulu, one on the island of Guam, and another at Cavite, in the Philippines. Others are designed, so that the commander of the Pacific squadron can always be in touch with his ships on the ocean.

Tests made by the department so far demonstrate several things of a peculiar nature. Messages can be transmitted better at night than in the daytime; better over water than over land, and better over land with long waves than with short waves. In tests made between Key West and Colon, about 1060 miles, communications were carried on at night, but not in the daytime, and the same results were obtained between Key West and San Juan. The longest distance over which ships have communicated at night is 1200 miles. The present aim, he said, is reliable communication, night or day, at 200 miles.

According to "The Mining and Scientific Press," the term "magnetic wells" has been applied to wells whose casings attract and hold iron objects. In the study of underground waters much interesting information concerning these magnetic wells has been obtained by members of the United States Geological Survey. Usually only small objects, such as nails, are attracted by the casings, but occasionally a well is found in which the magnetism is sufficient to hold hammers or wrenches. The water in the wells is sometimes reported to be magnetic.

Municipal Inspection of Wires

By T. C. O'HEARN

From a Paper Read Recently Before the International Association of Municipal Electricians

THE subject of inspection of wires brings up for consideration the following questions:—

First—What wiring should be inspected?

Second—Why this wiring should be inspected?

Third—How and by whom should it be inspected?

Fourth—What means should be at the command of the inspector to enforce the results of his inspection?

The third and fourth questions bear so closely on each other that they will be treated together.

Broadly speaking, all wires designed to carry electric current for any purpose whatsoever within the litmits of the municipality, and all apparatus connected therewith, should be subject to inspection. These include line wires—wires on the streets and highways designed to carry current for light, heat, power, signalling and the conveyance of intelligence—and interior wiring—wiring installed in buildings for the purpose of supplying light, heat or power, whether or not such wiring is connected to outside circuits, and in some cases wiring installed in buildings for signalling or for the conveyance of intelligence.

Primarily, the inspection of wires has for its object the protection of life and property. The lack of knowledge amounting almost to infantile innocence, displayed by the ordinary citizen in matters pertaining to electricity, adds to the responsibility of the inspector. The direct danger to life from electric wires is, no doubt, greater from line wires than from interior wiring, and except in a comparatively few unavoidable cases, such as during bad storms, there is no reason why, with proper care, accidents from the former cause should not be more rare than even they are now.

It would hardly be disputed that companies owning and operating electric lines desire to be free as possible from accidents, and there is no doubt that a large proportion of the serious accidents to persons on the streets from electric wires and poles are due to lack of inspection rather than to negligence in bettering conditions that are known to be bad. Danger to life from inferior wiring usually has its inception in a short circuit or a ground through the body, in the falling of a heavy chandelier, or in the conditions surrounding a fire caused by defective wiring.

It may be argued that the first cause is often the result of carelessness or ignorance. This is without doubt true, and such cases can be obviated only by a crusade of education in matters electrical, but this does not alter the facts where the cause is accidental. The fact that the accidents from interior wiring are often the result of accidents to outside wires shows the criminality, almost, of failing to inspect outside wiring.

Fortunately, from both a humane and a commercial point of view, personal accidents due to electricity are of comparatively rare occurrence. Electrical fires and burn-outs, however, are frequent enough to be considered not uncommon. Although the losses therefrom are not so great as from some other individual causes, they could be lessened materially and in many cases prevented altogether by a close inspection of the wiring.

As secondary considerations tending to show the beneficial results of a good inspection of wires, although it is not intended to use them here as arguments to prove its necessity, are the facts that rigid inspections tend to lower the rates of insurance and to save the members of a community from extortion by paying for the cost of good and safe work and materials, and getting poor and unsafe work and materials in return.

It must not be presumed, however, that good materials necessarily infer a good installation; materials not quite as good installed in a proper and workmanlike manner usually give a better result than the best materials improperly installed. In so far as an efficient inspection brings about good results in this latter direction, it eliminates much that is undesirable from the business of electrical wiring, thereby raising it to a more worthy and enviable plane, a consideration devoutly to be desired in any branch of business.

It is impossible to give in one place rules to cover the inspection of electrical wiring that would cover all the details for all the conditions that arise in all localities. The ground is best covered in this country by the "Rules and Regulations of the National Board of Underwriters," and although they cover the most salient points fully and admirably, there is, unfortunately, a sad lack of uniformity, and in some cases a gross display of ignorance in their interpretation.

Without doubt, faults may be found honestly with the code rules in some instances, but it cannot well be argued that the underwriters are not willing and eager to amend them when they are found to be wrong or unjust, or when new conditions make any part of them obsolete. The greatest fault with the rules is inherent in all laws that must possess sufficient elasticity to cover conditions in many various localities, governed by men of as many different temperaments and characteristics—they are susceptible of varied interpretations.

The underwriters' rules are, nevertheless, used to advantage throughout the country, either alone in their entirety or as a basis for a set of local rules, in which latter case they are usually adopted as a whole and further supplemented by rules to cover certain local conditions or eccentricities of the local inspector. This latter method of supplementing the Underwriters' rules with a set of local rules appears to approach most nearly to an ideal state of affairs.

It may be instructive to describe the beginning of an attempt in Massachusetts to extend these conditions, described above as ideal, over a comparatively large section. In May, 1904, several of the municipal inspectors of wires, in and about Boston, came together by prearrangement to consider the advisability of agreeing on an interpretation of the underwriters' rules; to adopt rules to cover conditions not covered

by the underwriters' rules or in some cases to be substituted for rules in the code; and if occasion should arise, to further the adoption of legislation beneficial to inspection departments. This first meeting was followed by others, at which large numbers were present, and the result was the formation of an association called the Massachusetts Association of Municipal Inspectors. The association is yet young, but good results are confidently expected from it.

Rules and regulations lose much of their force, however, unless supported by authority to enforce the usages they call for. The underwriters have only one remedy for failure or refusal to comply with the code—to refuse the risk. It is possible to suppose that insurance inspectors may close their eyes at a slight deviation from the code rules for the sake of getting more business, although the writer cannot say with authority that this is done.

However, the fact remains that they have as an alternative for poor wiring only the refusal to insure. The remedy is, obviously, to have the inspection of wires under the jurisdiction of the local government and controlled by State laws and ordinances, as are the departments of building, plumbing, health and whatever else pertains to the safety and comfort of the people.

In order to learn what others thought of the question "Who should control the inspection of wires?" letters were written to the inspectors in the various cities in Massachusetts. No towns were written to, the idea being to get returns only from places with as large a number of inhabitants as possible. Fourteen letters were answered. Nine stated emphatically that municipal authorities should inspect electrical wiring; three gave the information that no advantage could be gained by municipal inspection, and two were negative because there were no inspectors of wires in the cities to give an opinion. On the whole, the result is gratifying, especially to one who is familiar with the conditions in the cities from which the various answers were received.

Assuming that it is agreed that the municipality is to control the inspection of wires, it will be necessary that the municipal laws, or as they are usually called, ordinances, give the inspector the proper authority to enforce the requirements for good wiring and provide inadequate penalties for failure to comply with the laws. In order to best serve the interests in question, the writer believes that the ordinances should not give in detail the methods to be followed for wiring, but should generalize and be sufficiently flexible to allow new conditions to be met without the necessity of having amendments passed, with the customary bother and delay consequent thereto.

The best results are to be obtained if the regulations for wiring are covered in the ordinances by stating that "all electrical wiring for any purpose whatsoever shall be installed according to the rules and regulations of the Department of Inspection of Wires." In conjunction with this it will be necessary for the inspector of wires to compile proper rules and regulations, adopting the code, with additions, being the most satisfactory method, and have them printed together with the ordinances and distributed to electrical contractors. The contractors can then be kept informed of any changes in the rules, and when the conditions warrant it, the revised rules may be reprinted and distributed.

The general ordinance should provide that all electrical contractors be registered at the office of the inspector of wires; that a plan or description, or both, of the installation be filed with the inspector and a permit required for every piece of work; that no interior wiring be done until all gas piping, plumbing, steam and hot water piping, and all masonary and carpenter work, except such as will cover the wiring, are complete; that no lathing, sheating or other work that may cover the wiring be allowed to be done until the inspector certifies that the wiring has been inspected; and that no installation be connected to the mains until the inspector certifies that the installation is complete and satisfactory.

In addition it should be provided that any installation found at any time to be in an unsafe condition may be disconnected by the inspector and not be connected again except with his permission. A complete record of every inspection should, of course, be kept on file by the inspector.

It is a mistake to believe that once an installation has been connected to the service mains it is no longer to be considered under the control of the inspection department. By far the larger number of accidents from electrical wiring are caused by defects in old wiring—defects caused by accident, wear and tear and amateur work done after the final inspection. The only method to offset these accidents is to carry on a course of periodical inspections with a view of remedying the defects. This means a larger force in the inspection department, but there is no doubt that the results would warrant the increased expense. The writer knows of no place where this is done except in theaters and large department stores in the larger cities.

When municipal authorities and the general public come to a better realization of what it means to have electric wiring properly installed, municipal inspection will be more generally insisted upon. The rigidity of the inspection rests with the inspector of wires. Let him insist always on passing only good work and materials, and give the contractors to understand that inspectors will be prompt, thorough, effective and without favour; then he will find that from the beginning the best contractors will be ready to support him and to assist him in doing good work, thus making his work easier and more pleasant, and that before long all other classes of contractors will be forced to fall into line and bring their work up to the required standard.

Recent Practice in the Erection of Lightning Conductors

A REPORT, by Alfred J. Henry, professor of meteorology, dealing with recent practice in the erection of lighting conductors, was recently sent out by the Weather Bureau of the United States Department of Agriculture. The report first gives an interesting account of the erection of lightning conductors on the Washington Monument.

The conductors were begun in January, 1880, and finished in January, 1885, shortly after the completion of the monument. They consist of four hollow wrought-iron columns standing in the well of the shaft, and supporting the elevator machinery and guiding the car. They are made up of sections, 20 feet long, fastened together by long inside couplings. The bottoms of the columns rest upon, and are bolted to, cast-iron shoes, which are connected to ¾-inch soft copper rods led to the bottom of a well in the center of the foundation, water standing in it permanently, 2 feet 8 inches above the bottom. After the copper rods were inserted, the well was filled with clean, sharp sand for a depth of 15 feet 8 inches.

When the walls were completed, in December of 1884, and the upper extremities of the columns were covered in by the marble pyramidion, 4 copper rods, three-quarters of an inch in diameter, were run, one from each column, to the top stone, and

there united in a 1½-inch copper rod, which passing vertically through the stone, was screwed into a solid metal terminal of aluminum. This metal was selected for the terminal because of its whiteness, and the probability that its polished surfaces would not tarnish upon exposure to the air. It was a square pyramid in shape, similar to the pyramidion of the obelisk, and, fitting upon the top stone, completed the apex. The system was entirely completed and connected on January 20, 1885.

On April 5, 1885, during the passage of a heavy thunder cloud over the monument, at least 5 immense sparks or bolts of electrical light were seen within a period of 20 minutes to flash between the terminal and the cloud, without audible sound to the observers. A careful examination of the conductors and shaft failed to reveal any effects from these discharges.

On June 8, however, during a thunderstorm, a disruptive discharge was seen to pass between the summit of the pyramidion and the cloud. Upon examining the structure a crack was discovered in the stone on the north face of the pyramidion.

To devise if possible some plan by which the obelisk could be more effectually protected from lightning, Professors H. A. Rowland, of the Johns Hopkins University, Simon Newcomb, of the United States Navy, and T. C. Mendenhall, of the United States Signal Service, were invited to inspect the conductors and recommend modifications in them. The additions, as devised by them, consist of 4 one-half inch copper rods, fastened by a band to the aluminum terminal and led down the corners to the base of the pyramidion; thence passing through the masonry they extend inward and are joined to the iron columns above described. As these exterior rods are each over 60 feet long, they are also connected at two intermediate points of their lengths with the iron columns by means of copper rods one-half and three-quarters of an inch, respectively, furnishing sixteen rods in all connecting the exterior system of conductors with the interior conducting columns.

Where the exterior rods upon the corners cross the eleven highest horizontal joints of the masonry of the pyramidion, they are connected to each other all around by other copper rods sunk into those joints. All of these exterior rods, couplings, and fittings are gold plated, and are studded at every 5 feet of their lengths with copper points 3 inches in length, gold plated and tipped with platinum. There are 200 of these points in all.

As regards the lightning rod industry, in 1860 the United States Census showed that 20 establishments turned out rods to the value of $182,750. In 1870, the number rose to 25, and the value to $1,374,-631. Finally, in 1890, the number of establishments was 22, and the value of the product $483,296. In 1900, lightning rods were tabulated in the general classification of foundry and machine shop products.

While there are no means of determining whether the decrease, from 1870 to 1890, is due to a decline in the use of rods, it is certain that the "Lightning Rod Man" is not so much in evidence as he was in the early seventies.

Then follows the report of the British Lightning Research Committee, which has already been abstracted in these pages. In conclusion, the report describes the practice current in Holland, Hungary and Germany.

A New Single-Phase Commutator Motor

In a paper read recently before the British Institution of Electrical Engineers, V. A. Fynn described a new constant-speed, single-phase commutator motor possessing many interesting features. To help to the full understanding of the new motor, the author first considered the forms of single-phase motor shown in Figs. 1 and 2.

The primary member is magnetized along an axis F by means of the winding S. The secondary member, which consists of an armature provided with a continuous-current winding connected to a commutator, is short-circuited by means of the brushes CC and DD along two perpendicular axes, one of which coincides with the field axis of the primary member or stator.

Such a commutator motor has all the characteristics of the asynchronous single-phase, squirrel-cage motor; in fact, the latter is only a special case of the former. It is easy to see that two axes are the smallest number along which such a rotor can be short-circuited in order to work at all; any further increase in the number of short-circuits does not alter the nature of the motor.

Thus, instead of what might be termed the 2-phase short-circuiting arrangement shown in Fig. 1, a 3 or 4 or more phase short-circuiting arrangement could be used with the same result. If the number of short-circuits is chosen so high that the whole of the commutator is covered by brushes, in other words, so that the whole of the commutator is short-circuited, then the latter can obviously be done away with and its place taken by a continuous ring.

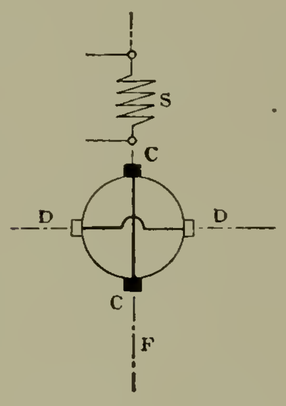


FIG. 1

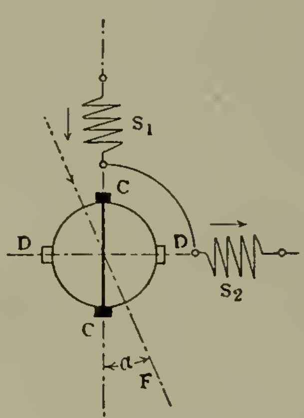


FIG. 2

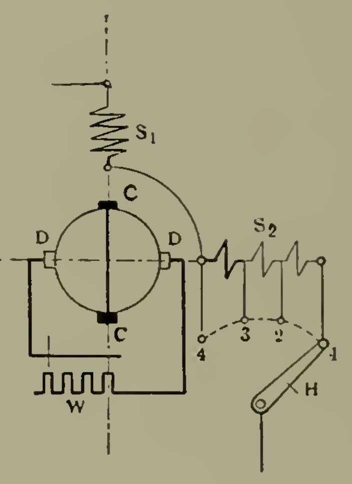


FIG. 3

We thus arrive at the simple form of the squirrel-cage rotor.

The motor in Fig. 1 will not start; if brought up to speed artificially, it will do useful work running somewhat below synchronism, but its power factor is bad, it is very liable to spark at the commutator, and its output for a given weight is small. It is probably on account of these inherent defects that this motor never came on the market.

In Fig. 2 we have a stator winding divided into two groups, S_1 and S_2, connecting in series. The axis of the group S_1 coincides with the axis along which the rotor is short-circuited. In this axis CC we have all the conditions of a transformer, the rotor representing the secondary, and the stator group S_1 representing the primary. It follows that un-

der all conditions the rotor current will be (omitting sign) very nearly in phase with the current in both stator groups, since they are in series.

The field in the axis of S_1, called the transformer field, is due to the magnetizing component of the transformer no-load current; the latter is represented in phase and magnitude by the resultant of the primary and secondary currents. The field in the axis of S_2 is due to the total current flowing through the stator, and is in phase with it, consequently very nearly in phase with the rotor current.

This second field induces no current in the rotor, but, with the rotor current induced along the transformer axis, it produces the motor torque. This second field is called the motor field. We, therefore, have precisely the same conditions as exist in the series conduction motor, except that in the present case the current is not conveyed into the rotor by conduction, but by induction. It is from this fact that the motor takes its name of series induction motor. The direction of rotation is, in both types of motor, determined by the same rules, and the torque is due to the same causes.

The disposition shown in Fig. 2 allows of the direction of rotation being reversed by reversing the current either through S_1 or S_2, but there is no provision for regulating the starting current or the torque, and when the motor has been brought up to speed, the brushes being displaced in the direction of rotation, the current in the *D* circuit will fall off, while that in the *C* circuit will rise, the line pressure and the load on the motor remaining constant.

These difficulties are gotten over by the arrangement shown in Fig. 3. This makes it possible to reduce the current taken by the motor, when switched on to the mains, to any desired amount, and it allows of this motor being gradually started and brought up to its normal speed without the use of the usual resistances, transformers, or the like; all that is necessary is a switch such as shown at *H* connected to the various tappings provided in the group S_2. With the help of this switch, the group S_2 can be finally switched out altogether, thus enabling the motor, after it has been converted into a shunt induction machine, to work under the most advantageous conditions, current being supplied to the group S_1 only.

The motor starts as a series induction motor, and the greatest torque is secured with the *D* or field brushes on open circuit; were they short-circuited from the very first, this short-circuit in the motor field axis would necessarily alter the phase of the motor field and bring it into nearer coincidence with the transformer field, thus increasing the phase discrepancy between the armature current (axis *CC*) and the motor field, and greatly reducing the torque.

As the speed increases, the *D* circuit can be closed over resistances and these can be gradually cut out, the motor acquiring by degrees the characteristics of what is known as the asynchronous induction motor. If care is taken to close the *D* circuit at about synchronous speed, the resistances can be dispensed with, and they are not provided with the small motors.

It has been shown that the motor in Fig. 1 is electrically the equivalent of a motor with a squirrel cage; it must, therefore, also behave like a motor having a rotor provided with a polyphase winding, short-circuited by means of slip-rings or otherwise; nothing in the nature of the motor would, therefore, be changed if, in addition to the two sets of brushes on the commutator, say, three equidistant points of the rotor were short-circuited when up to speed.

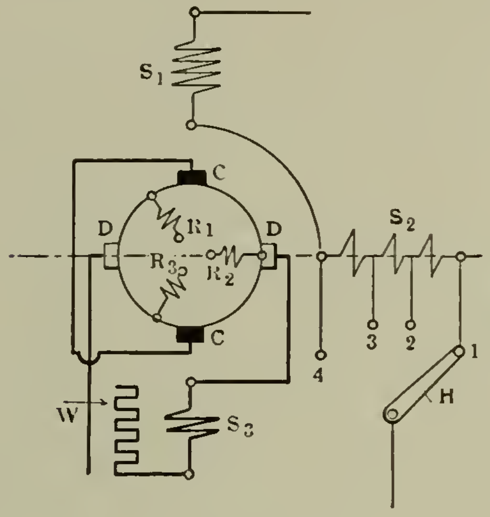


FIG. 4

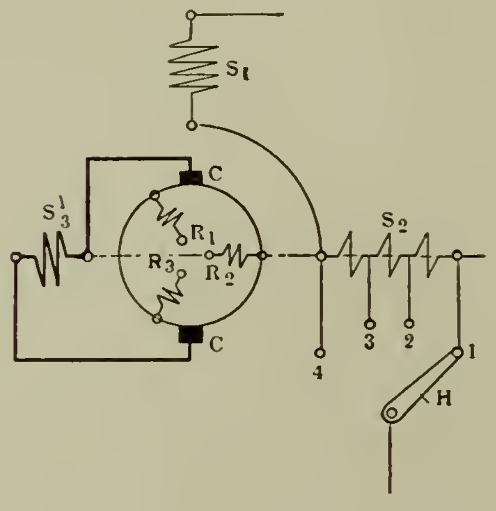


FIG. 5

This was done to relieve the commutator of the greater part of the current it was carrying, and thus diminish sparking. The sparking was, indeed, entirely suppressed. The same arrangement was used at starting, when resistances between the three equidistant points were inserted by means of slip-rings, and gradually cut out as the speed was increased. It was, however, found that the ordinary rotor windings in use did not answer the purpose at all well, particularly when phase compensation was attempted.

It is easy to see that with a number of points of the rotor winding directly short-circuited, for instance, over slip-rings, any e. m. f. impressed on the rotor by means of the one or the other brush set would send a heavy and useless current through these slip-rings; phase compensation is practicably impossible under such circumstances. Then, again, it is advantageous to have a very low voltage on the commutator, whilst a high voltage on the slip-rings is important.

An obvious way out of the difficulty is to use two distinct windings on the rotor, the one connected to the commutator, and the other to the slip-rings. This arrangement lowers the output of the motor very appreciably, because it makes it impossible for that part of the winding which is connected with the commutator to be made use of in normal running (when the machine operates as a shunt induction motor), as almost the whole of the current induced in the rotor will flow through the slip-rings.

To get over the difficulty completely, the author makes use of a continuous-current and polyphase winding in his rotors, combined in such a way that, as far as the commutator is concerned, only the continuous-current winding is operative; whilst both continuous and polyphase windings are operative as far as the slip-rings are concerned. The best possible use is thus made of the rotor winding space and copper. The commutator voltage depends on the continuous-current winding only. The polyphase winding is so disposed with regard to the continuous-current winding as to obtain at the slip-rings the highest possible voltage resulting from the combination of the two windings.

The complete motor is shown diagrammatically in Figs. 4 and 5 in its two early forms, as arranged for "constant-speed work." For the

sake of clearness, the slip-rings have been omitted from the figures; they are connected to the points R_1, R_2, R_3 of the motor winding.

The arrangement shown in Fig. 4 allows of the conversion of the motor from a series induction to a shunt induction machine by the gradual closing of the D circuit in combination with a gradual reduction of the number of turns in the group S_2, and, when desired, also in combination with a gradual decrease of the resistances inserted between the slip-rings. Reduction of the resistances inserted in the D circuit and a reduction of the resistances between the slip-rings increases the shunt excitation; a reduction of the number of turns in the group S_2 after the motor has started reduces the series excitation. At first both methods were used simultaneously on account of sparking difficulties, and one was naturally led to simplify this disposition by leaving out the D circuit altogether. The motor shown in Fig. 5 was thus evolved, and quite a number of such machines were built.

The conversion from series induction to shunt induction working cannot be effected as smoothly with the help of the slip-rings only (Fig. 5) as it can with the help of the D circuit (Fig. 4); and in the former case it is quite impossible in practice to avoid a very marked falling off in the starting torque curve, which makes this form of motor unsuitable when heavy and sustained starting torques are required. For light work, however, it is very useful, and its power-factor under normal working conditions approaches unity. On the other hand, the starting torque curve of the motor in Fig. 4 (with or without the help of slip-rings) is an almost straight line, and the motor in this form can be used for all those cases in which heavy and sustained starting torques are required, —for instance, for lift and similar work.

The slip-rings are a very unwelcome complication, at any rate for smaller machines, but a way was found for doing without them by simply suitably dimensioning the rotor winding.

The average results which can be obtained from such motors vary somewhat with the periodicity of the supply and the number of poles of the motor. Taking as a basis 50 periods, and what can be considered as a nominal number of poles, and further assuming that the voltage at the terminals is not raised at starting above the value for which the motor is designed, a maximum torque, two to two and a half times the normal, can be secured with about one and a half times the normal current. The motors will start light with about no load current, or not more than one-fourth of the normal current.

The power factor can always be brought up to unity; this, however, may entail a heavier current in the rotor and slightly higher losses. On that account the smaller motors are not, as a rule, fully compensated, as it does not appear advisable to lower the efficiency for the sake of improving the power factor by some 5 per cent. Thus, for small machines up to 6 or 7 H. P., the power factor is only raised to 0.7 or 0.8 at no load, reaching 0.9 to 0.94 under load. The power factor curve rises very rapidly at first, and as the load increases it remains nearly constant. The larger machines are designed for a power factor seldom falling below 0.9 and reaching 1; these can be made to take a leading current when desired.

The efficiency of these compensated motors closely approximates to that of good asynchronous machines with squirrel-cage rotors. In the smaller sizes it falls some 2 to 3 per cent. below the latter, as is to be expected; since for small outputs only a small increase in the losses is sufficient to reduce the efficiency by several per cent. In this case the increased losses are mainly due to the friction of the brushes on the commutator and to the I^2R losses in commutator and brush gear. In the larger sizes the efficiency quite equals, and sometimes, for a large number of poles and high frequencies, materially exceeds that of the corresponding asynchronous motor. Altering an ordinary asynchronous single-phase motor to the construction which has just been described will increase its output from 30 to 40 per cent., besides vastly improving its power factor; but the increased output and the better power factor of these machines do not entirely compensate for the increased losses.

Annual Convention of the American Street and Interurban Railway Association

According to a preliminary announcement sent out by the American Street and Interurban Railway Association, the convention this year will be at Columbus, Ohio, during the week of October 15 to 20. The several associations which will meet at the convention are as follows:—The American Street and Interurban Railway Association, the American Street and Interurban Railway Accountants' Association, the American Street and Interurban Railway Engineering Association, American Street and Interurban Railway Claim Agents' Association, American Street and Interurban Railway Manufacturers' Association.

Columbus is the state capital and has successfully taken care of many large conventions. It possesses four large well-appointed hotels, as well as several first-class smaller ones which collectively can guarantee about eleven hundred rooms, many of these with bath, if desired. The rates for one person, on the American plan, vary from $2 upward, and on the European plan, from $1 upward. Those who desire to do so can make reservations now, by addressing B. H. Harmon, secretary, convention committee, Columbus Board of Trade, Columbus, Ohio.

Excellent facilities have been provided for the manufacturers' exhibition, which has become such a feature of the national street railway conventions. The exhibit halls are located on the State Fair Grounds, which are within fifteen minutes' ride of the principal hotels. There are six adjoining brick exhibit halls; four buildings, 110 feet by 200 feet, and the other two, 100 feet by 150 feet. In addition, there are three covered sheds with brick pavements, 100 feet wide by 400 feet long. The Manufacturers' Association will have a larger and more comprehensive exhibit than ever in the past. The Big Four Railroad tracks will be run directly up to the buildings.

The assembly or convention hall is 80 feet by 100 feet, comfortably seating from 600 to 800 people, and is in close proximity to the exhibition halls. If desired, one of the six buildings can be used for the convention hall, with a seating capacity of 1500 people. All the buildings can be heated by natural gas and will be lighted by electricity. Sufficient power to operate exhibits will also be available, both 500-volt direct-current and 110-220-volt, 60-cycle alternating current.

President Ely has appointed a convention committee, which will have these general matters in charge, and a second announcement containing more specific details of the convention will be issued within a short time. Bernard V. Swenson, 60 Wall St., New York, is secretary of the association.

Thirteen years ago the first independent telephone plant was installed at Noblesville, Ind.

From the World's Technical Press

Electrolysis by Alternating Currents

UNDER ordinary circumstances, says "Engineering," of London, one might think there should be no such thing as alternating-current electrolysis, for the metal which the anodic current impulse dissolves should be precipitated again by the next cathodic impulse, and the solution remain unchanged.

This is in a certain measure correct for symmetric currents in which both impulses are of the same duration and identical, apart from the direction. But polarization, current density, temperature, diffusion, chemical affinities, and solubilities complicate the problems so much that the effect cannot be predicted.

Copper cannot be precipitated from its solution in potassium cyanide by continuous currents because, it is assumed, the copper forms complex ions in this solution. The formation of these ions must take a certain, though very small, time. If we apply asymmetrical alternating currents of high frequency, we may succeed in changing the current direction before the copper ions have had time to enter into complex combinations, and thus we may stop the further solution of copper by the cyanide.

As a matter of fact, Le Blanc finds that, while with 1000 current alternations per minute, the dissolution of the copper proceeds quantitatively as with continuous currents, it becomes less with higher frequency, and has diminished to one-third of its original value when 38,000 alternations are applied.

The behaviour of platinum electrodes in particular has occupied many investigators. Continuous currents do not dissolve platinum. Alternating currents dissolve it according to some investigators, and only tend to weaken its cohesion according to Margules, Ruer, and others.

Brochet and Petit believe that the frequency does not matter in the case of platinum electrodes when in cyanide solutions. They maintain that neither direct nor alternating currents will alone dissolve platinum in dilute acids, but that combined direct and alternating currents will do so. The chief condition is, in their opinion, that the current strength should fluctuate; interrupted direct currents should hence also have powerful solvent effects. All these are laboratory experiments, however.

In their attempts to utilize waste alternating currents for the electrolysis of water, Van Name and Gräfenberg observed that all electrodes, including platinum, irridium, and gold, would corrode in dilute sulphuric acid, and that iron, nickel, copper, and silver did not any better resist the action of dilute alkalies if continued for longer periods. The electrode difficulty would certainly be great in commercial alternating-current electrolysis.

Electric Hoisting Engines

THE reasons why electricity has not been more widely used for driving large hoisting engines in mine work are given by George P. Scholl, in the "Mining Magazine," as follows:—

Its operation has to be absolutely sure, and the liability to accidents almost eliminated. The hoisting speed must never exceed a certain specified amount. Provision must be made to guard against overwinding, and to prevent a sudden stoppage of the cage at the pit mouth. It should be possible to run the engine in a simple manner, and the driver should always have complete control over it.

On account of the multiplicity of conditions to which the electric drive of hoisting engines has to conform, its introduction has been slower than should have been expected. But the last few years have seen a great change in this respect, especially on the continent of Europe.

The first installations of electric power to drive hoisting engines were such that, as with the large steam engines, a great deal of energy was uselessly consumed in the rheostats and the controlling appliances. It is absolutely essential that the speed of hoisting can be varied, in order to work at full speed when materials are hoisted, or at half speed, as usual, when persons are carried, or even at very low speed, for the purpose of examining the rope.

In order to obtain this speed regulation, it is possible to use either triphase motors or direct-current motors of the shunt-wound or separately excited type. If it is necessary to use triphase current on account of the power being transmitted from a distance, it will, of course, be more advantageous to install this type, but all things considered, the direct current presents a number of advantages, as far as the speed regulation and energy consumption are concerned. It will usually be found advisable to combine the triphase current for generation and transmission of energy with the direct current for actuating the hoisting engine.

Electro-Zincing Iron and Steel to Make it Non-Corrosive

ALTHOUGH electro-zincing, or depositing zinc by electricity, was practiced before hot or molten galvanizing, it was abandoned on account of the difficulties encountered. The chief trouble, according to Sherard Cowper-Coles, in "The Iron Trade Review," was the uncertainty as to the quality of zinc deposited and the formation of zinc sponge. Also, efficient low-tension dynamos could not be obtained at that time.

The process was successfully re-introduced about ten years ago, the difficulties which had been met with before were overcome, and the operation has been rendered so simple by the introduction of the regenerative process that any inteligent workman can use it.

The process, briefly, consists of placing the article to be coated in a solution of zinc sulphate with or without aluminum sulphate. Zinc or lead plates are suspended in the bath through which the electric current is conducted into the solution. The zinc plating solution is circulated by means of compressed air or a centrifugal pump through the depositing tank constructed of broken coke and zinc dust. As the solution passes through the filter bed the zinc dust is dissolved, thus replacing the zinc which has been electro-deposited on the ironwork that is suspended in the bath.

Small articles, as bolts, nuts, etc., are electro-galvanized by placing them into a revolving drum or barrel suspended in the zincing solution. One of the latest arrangements consists of a drum mounted in bearings. Within the drum a helical plate provides a continuous helical channel around the inside of the drum. In this channel the articles travel by gravity from one end to another as the drum is rotated.

The cost of zincing 15 tons of small articles per week of seventy-five hours with 1¼ ounces of zinc per superficial foot is $11.77. Large articles, such as plates, can be electro-zinced at $3.75 per ton.

A New System of Electrically Welding Rail-Joints

Since the introduction, about twelve years ago, of continuous rails with welded joints for street railway track, three kinds of welded joints have come into more or less general use in this country and abroad, namely, the Falk, or cast-welded joint; the Lorain, or the joint which is electrically welded by means of current from a transformer; and the Goldschmidt, or thermit-welded joint.

According to "The Street Railway Journal," a fourth method is now being employed in Germany on several railways. It is being exploited by the Accumulatorenfabrik Aktiengesellschaft, of Hagen and Berlin, and it is a modification of the electrically welded joints. It does not depend, however, upon the production of a welding heat by the resistance and transformer method, as in the Lorain system. Instead, a high temperature is secured by the use of a large electric arc, which melts a quantity of steel at the joint.

The negative pole of this arc is formed by the rails themselves, and the positive pole is a carbon supplied with direct current from a special generator and other apparatus provided for the purpose. The carbon or positive pole is attached to a holder, so that it can be moved back and forth by hand over the pieces of steel, which are to be reduced to a liquefied condition at the joint to form the welding portion. During this process the joint itself is held in a form or mould, so that as the metal melts it flows underneath and around the base and under the head of the rail.

A small quantity of steel is first melted, and additional steel is fed into the arc until enough has been melted to form the weld. The steel employed is of the same composition as that used in the rail itself, and is obtained from old rails. The system has been employed to a considerable extent for joint welding by a number of the electric railway companies in Germany during the last few years, and has also been applied to welding steam engine cylinders, power shears, broken gears, and for other industrial purposes.

A New German Metallic Filament Lamp

According to "The Electrician," of London, Dr. Hans Kuzel, of Vienna, has given the results of a series of tests on a new German metallic-filament lamp. The first lamp was rated at 32 volts, 13.17 candle-power, 0.461 ampere and 1.12 watts per candle-power. The test was started at 0.461 ampere, the current just before the lamp burned out 1468 hours later being 0.472 ampere. The filament in the loop after 1010 hours burnt through, rejoined itself and went on burning. The watts per candle-power diminished gradually from 1.12 to 1.002 at the end of the life of the lamp, two or three readings showing some variation, however, from this downward trend.

The second lamp was rated at 30.25 volts, 12.39 candle-power, 0.461 ampere and 1.08 watts per candle-power. The lamp was still burning after 3537 hours, it having burned through and rejoined at 1490 hours. In this instance the watts per candle-power showed, in general, a slight increase as the test proceeded.

A test was next made upon a lamp of 19 volts, 29 candle-power, 1.48 amperes and 0.97 watt per candle-power. After it had burned for 1686 hours the current was increased by raising the pressure to about 60 volts. In consequence the filament burned through, but rejoined, and the lamp went on burning. The amperes in this case remained very nearly constant, as did the watts per candle-power, except, of course, when the overload was put on.

Another lamp of 30 volts, 13.5 candle-power, 0.470 ampere, 1.05 watts per candle-power, was still burning after 3103 hours, the amperes and watts per candle-power remaining practically constant.

Two other lamps tested showed practically the same characteristics. Two more were supplied with excess current, one 233 per cent. and the other 201 per cent., and this without damage. In the second case the only result was that the normal candle-power of 19½ was increased to 20½.

Electricity in Paris

Until 1888, according to "Engineering," of London, there seemed to be no prospect of any central electric station ever being put down in Paris. The delay was due to the attitude of the Paris Municipal Council, who ignored all private schemes in their desire to establish one of their own as soon as they deemed it advisable.

In the year mentioned, however, a plan was arranged for granting a number of concessions, with the idea of ultimate municipalization. The city was divided into a number of districts, with one concession for each. To prevent the formation of a monopoly, any district was forbidden to amalgamate with a neighbouring one.

The municipality reserved the right to authorize any outside firm to lay mains in any district, or to lay mains on their own account for a separate municipal undertaking. An independent municipal station was put down at Halles, for lighting the markets and supplying customers in the vicinity, the alleged object of this being to ascertain the best system of current distribution.

Under the conditions of the concessions, the companies were obliged to run their lines underground, the work being supervised, and the direction, section, and depth of the conduits being determined by the municipality. No junctions were to be laid across the roadway, but separate lines had to be laid on each side

of the street, except where it was too narrow. Manholes were to be provided to permit inspection, and of such dimensions as to allow of replacing a cable without excavation.

The most onerous clause was that limiting a concession to eighteen years only, absolutely prohibiting, under penalty of cancellation of the concessions, one concessionnaire combining with another, or handing over his rights to a third without the consent of the city.

A maximum rate was fixed at 30 cents per kilowatt-hour for lighting and $13\frac{1}{2}$ cents for power, with a special rate for the city. Clauses as to the length of working day and the pay of employees were also inserted. The companies were assessed an annual royalty of about $30 per mile of leads, plus 5 per cent. of the gross receipts, or 6 per cent. when the stations were outside the city boundary, to make up for town duties evaded. The city also reserved the right to withdraw the concession at any time after the first ten years.

	Company No. 1	Company No. 2	Company No. 3	Company No. 4	Company No. 5	Company No. 6
Capital	$1,930,000	$12,159,000	$1,930,000	$2,895,000	$965,000	$4,053,000
Paid off on capital	723,750	3,088,000	1,843,150	656,200	......	92,270
Annual royalty	......	68,515	31,073	47,478	48,250	38,600
Arc lamps	2,270	4,974	5,239	1,300	876	1,527
Incandescents	219,000	238,000	107,000	245,000	360,000	179,000
Paid yearly to sinking fund	386,000	990,090	239,320	386,000	289,500	......
Annual dividends	183,350	......	103,448	104,220	96,500	......

At the expiration of the concession the mains became the property of the city, which could cause their removal at the company's expense. In this case, further, the municipality did not guarantee that it would take over the central station and the bulk of the company's plant.

Notwithstanding the severity of these conditions, six companies put in a tender for concessions in 1888; four of these were able to deposit the security required, and took steps for working their sections. The concessions of these companies come to an end in April, 1907. In 1890 two other companies obtained the concessions for the two remaining sections. The first generating stations were put down within the town limits; a number of these are still working, but others have been replaced by stations built outside the fortifications, thus increasing largely the amount the companies have to provide for sinking fund.

The financial results obtained by the six companies may be summarized as follows:—

The public and promoters who placed their money in the undertakings have received hitherto but little, if any, remuneration; and the comparatively short time allowed for the concessions has compelled the companies to take, where these were possible, energetic means to provide for redeeming their plant, thereby charging the public high rates for their current supply.

If the municipality, when the concessions lapse and are not renewed, do not take over the installations made by the companies, the latter will have great difficulty in getting rid of them. This, however, is an eventuality which is little to be feared, as the Paris authorities are now more than ever bent on municipalization, notwithstanding the fact that, as regards electric current distribution, the Halles central station, briefly alluded to before, and worked by the municipality, has given very poor results.

The municipality may demand, when the concessions lapse, that the installations be worked en régie, entirely under their control; but this might lead to a deadlock, as the companies can refuse absolutely to give their sanction. The only reasonable way would be to grant the companies a new lease to enable them to redeem their plant without having recourse to exaggerated measures, and, as a consequence, to lower the price at which they sell their current.

The Preservation of Telegraph and Telephone Poles

IT has been estimated by the "Mining and Scientific Press" that with the life of telegraph and telephone poles at its present limit, the 800,000 miles of existing lines, requiring 32,000,000 poles, must be renewed approximately four times before trees suitable to take their place can grow.

A pole lasts in service about twelve years, on the average, but is made from a tree about sixty years old. In other words, to maintain a continuous supply, five times as many trees must be growing in the forest as there are poles in use. The severity of this drain upon forest resources by the telephone and telegraph companies is obvious enough.

Since 1902 the Forest Service has been making a study of the preservative treatment of poles and of the value of the seasoning in relation to treatment. In this work its first object has been to make the timber last as long as possible, so as to check the annual demand for renewal, and thus lessen so far as possible the drain upon the forest.

Seasoning was studied in the first place to determine the rate at which poles become air dry, that is, lose as much moisture as they will part with through evaporation in the open air. The time of cutting was also carefully considered. Experiment proved that poles cut in winter dry more regularly than those cut at other seasons, and also show a greater loss in moisture at the end of six months' seasoning. The disadvantages of winter cutting are, therefore, even drying, with a minimum liability to check, and light weight,—an obvious advantage for shipment by freight.

Spring or summer cutting secures a more rapid loss of moisture at first, owing to the temperature, but only for three or four months. At the end of from six to eight months, spring and summer-cut poles are found to have dried only three-quarters as much as winter-cut poles. Spring and summer cutting, however, would result in saving in freight and increased durability if the poles are to be shipped and used within three or four months after cutting.

Electricity in European Oil Fields

THE first European wells to be drilled by electric motors were those in Roumania, says "Mines and Minerals." This was nearly seven years ago, and the total capacity of the electrical station was only 200 kilowatts, but it was sufficient to operate the drills in the whole region.

The German engineers have developed electrical drilling and pumping in the oil regions of Roumania to a considerable extent since this first installation. They constructed an electrical plant for the Roumanian company, Steana Romana, a few years ago which shows the latest improvement in electrical oil drilling. Hydraulic power is used for generating the electricity, and the turbine plant furnishes 1500 horse-power for the oil region nearby. Upwards of fifteen wells can be handled by this plant, and with further extensions of the property twenty to thirty wells will be brought under control.

The power house is situated 20 miles from the oil fields, and current is transmitted to the different wells along the route. A set of transformers raises the voltage to 11,000 for the high-tension line. Four dynamos of the three-phase type, giv-

ing 300 volts each, are installed at the power house. A reserve station has recently been constructed near the wells, so that in case of accident to the central station, operations would not be suspended. This reserve station is supplied with three Diesel motors of 300 horse-power each, and as they burn crude oil direct from the fields their cost of operation is very small.

Fires in the oil fields of this country are fully as numerous and destructive as in Russia, and the waste of energy by using individual steam units or oil engines for each well is a factor of no small importance. Where steam pipes are used for carrying steam to distant wells, the loss through condensation is considerable, and its remedy is more easy to suggest than in coal mines.

The adoption of electricity for different kinds of mining operations is one of the interesting questions of the day, but if there is one field that should show especial benefit from this it is in mining for oil. And this particular field has shown the least responsive appreciation of the opportunities offered by the central station idea from which electric power can be run on overhead wires to hundreds of different wells.

Properties of Tantalum

PARTICULARS of the metal tantalum are given in London "Engineering," supplementary to those printed in earlier issues of this paper.

According to these, larger quantities of the metal are prepared by the method of Berzelius and Rose, by the action of alkali metals on the alkali tantalum fluorides and subsequent fusion of the metal powders thus obtained with the electric arc. The product before refining in the arc contains 98.5 to 99 per cent, of metal; it is then compressed and heated in an electric arc in a vacuum, the oxides of tantalum fuse, and are dissipated in the form of dust much more readily than the metal, and it is possible to free the latter from them completely, and thus obtain ingots of the perfectly pure metal. The following are the physical constants of pure tantalum:—Its atomic weight is 183; the melting point is between 2250 and 2300 degrees C.; specific heat, 0.0365; atomic heat, 6.64; specific gravity of fused metal, 16.64, and of wire, 0.05 millimetre in diameter, 16.5.

When the wire is heated to whiteness in a vacuum it becomes denser and crystalline, its specific gravity finally reaching that of the fused metal. The coefficient of linear expansion from 0 degree to 50 degrees = 0.0000079. Specific resistance, 0.165 ohm for a wire 1 metre long and 1 square millimetre cross-section, or ten times that of copper. The resistance increases 0.3 per cent. per degree C. between 0 and 100, and 0.26 per cent. per degree between 0 and 350. The modulus of elasticity of the wire (0.08 millimetre in diameter) is 19,000 kilogrammes per square millimetre, its breaking stress 93 kilogrammes per square millimetre; this increases as the diameter of the wire decreases, reaching 150 to 160 kilogrammes per square millimetre for wire 0.05 millimetre thick. The extension of the wire before breaking is small, being only 1 to 2 per cent., notwithstanding which wires of 0.03 millimetre in diameter can be drawn.

Tantalum is very ductile, but possesses the remarkable property of becoming extremely hard after hammering. An ingot of the metal beaten out under the steam hammer to a sheet 1 millimetre thick was drilled with a diamond drill making 5000 revolutions per minute for 72 hours continuously, after which a depression of about $\frac{1}{4}$ millimetre was found, the diamond drill being much worn. In chemical properties tantalum approaches the noble metals, and in dilute nitric acid it stands between platinum and silver as to its electrochemical properties. Immersed in dilute sulphuric acid tantalum only allows currents to pass when it is the cathode; when it is the anode no current passes even with 220 volts, owing to the formation of a film of oxide. Its electrical dissipation as dust when used in a vacuum is extremely small, and whilst its useful life as a filament in electric glow-lamps is as great as that of carbon, the electrical energy consumed is less than half. When a tantalum filament is used, its temperature being such that 1.5 watts produce 1 candle-power, the resistivity rises to 83 micro-ohms per centimetre cube. Thin filaments, when ignited, burn with a low intensity and no visible flame.

At a low red heat tantalum absorbs hydrogen as well as nitrogen, and forms with these a brittle substance of metallic appearance. It also forms a number of carbides, all of which are very brittle. It is not attacked by aqueous solutions of alkalies, and only by one acid—viz., hydrofluoric. Compact tantalum may be etched by this acid; the appearance of the surface affording a good guide to the purity of the metal. The action of hydrofluoric acid is very slow, unless the tantalum is in contact with platinum. Fused alkalies cause disintegration of the metal. Compared with platinum, its appearance is somewhat darker, and its thermal expansion rather less—viz., 7.9 by 10^{-6} compared with 9.0 by 10^{-6}. Compared with steel, its tensile strength is higher, for, according to Kohlrausch, the relation is 60 tons per square inch against 45 to 50 tons per square inch. Tantalum may be made to take up large quantites of hydrogen, which is not driven off completely even by fusion, the fused metal being hard and brittle. Traces of hydrogen, however, do not affect its ductility. Compact tantalum, when heated in the air, becomes yellow at 400 degrees, blue at a temperature corresponding to a dull red heat, and is finally covered with a layer of the white pentoxide which protects the metal below it; thin wire burns with a white light without flame. Metallic tantalum heated to whiteness does not combine with oxygen if its pressure is less than 20 millimetres, and this explains the preparation of the metal by heating the oxide in a vacuum. When heated in nitrogen it becomes dull, grey, and brittle, and the powdered metal readily combines with sulphur, selenium, and tellurium.

Iron alloys containing 5 to 10 per cent. of tantalum are very hard and ductile. Molybdenum and tungsten alloy readily with tantalum; the alloys containing less than 5 per cent. of these metals are ductile. Silver and mercury do not alloy at all with it. More than 1 per cent. of carbon renders tantalum too brittle to be drawn into wire, but if it contain 0.5 per cent. of carbon, it can still be drawn into wire 0.1 millimetre thick. Traces of carbon, boron, and silicon add to its hardness without diminishing its ductility. The Siemens and Halske Aktiengesellschaft, employing von Bolton's methods above described, obtain crude tantalum by reduction with sodium. This always contains oxide, which may be removed by fusion in a closed exhausted electric furnace. The crude tantalum, compressed into a crucible of thoria or magnesia, forms the anode; the cathode consists of a rod of pure tantalum or silver, which is movable from the outside of the enclosing vessel. An arc is started, and is then caused to travel over the whole anode surface, when fusion to a homogeneous non-porous mass occurs. For a 110-volt lamp of 25 to 32 candle-power, with wire of 0.05 millimetre in diameter, the filament is 65 centimetres in length; its mass

is 0.022 grammes, so that 1 pound of tantalum would serve for 23,000 lamps. Such lamps absorb 1.5 watts per candle, against 3.5 watts for a carbon filament; and they last 400 to 600 hours before the efficiency diminishes 20 per cent. It is hoped to employ the metal and its alloys for the production of engineers' machine tools on account of its great hardness and strength.

Milwaukee Convention of the American Institute of Electrical Engineers

THE twenty-third annual convention of the American Institute of Electrical Engineers will be held at Milwaukee from May 28 to June 1. The date was changed from late in June so that members might also take part in the European trips.

The programme for the convention is as follows:—

MONDAY, MAY 28

Address by President Schuyler Skaats Wheeler.

"Repulsion Induction Motor," by Maurice Milch, associate A. I. E. E.; engineer, General Electric Company, Schenectady, N. Y.

"Direct-Current Motor Design as Influenced by the Interpole," by Charles H. Bedell, associate A. I. E. E.; head of laboratory, Electro Dynamic Company, Bayonne, N. J.

TUESDAY, MAY 29.

"Experience with Lightning and Static Strains on 33,000-Volt Transmission System," by Farley Osgood, associate A. I. E. E.; general manager, New Milford Power Company, New Milford, Conn.

"Cell-Type Lightning-Arrester," by E. E. F. Creighton, associate A. I. E. E.; assistant professor of electrical engineering, Union University, Schenectady, N. Y.

"Protective Apparatus for Lightning and Static Strains," by H. C. Wirt, associate A. I. E. E.; engineer, supply department, General Electric Company, Schenectady, N. Y.

"Short-Circuit and Ground Currents in Alternating-Current Systems," by Charles P. Steinmetz, member A. I. E. E.; electrician, General Electric Company, Schenectady, N. Y.

WEDNESDAY, MAY 30.

"Magnetic Properties of Electrolytic Iron," by Charles F. Burgess, member A. I. E. E.; professor of applied electrochemistry, University of Wisconsin, Madison, Wis., and A. Hoyt Taylor, University of Wisconsin, Madison, Wis.

"Measurement of Temperature by Electrical Means," by Edwin F. Northrup, associate A. I. E. E.; secretary, Leeds & Northrup Company, Philadelphia, Pa.

"The Educational Value of an Electric Test-Car," by T. F. Morgan, assistant professor of electrical engineering, University of Illinois, Urbana, Ill.

"The Art of Inventing," by Edwin J. Prindle, associate A. I. E. E.; patent attorney, New York.

"Shunt and Compound-Wound Converters," by W. L. Waters, member A. I. E. E.; chief engineer, National Electric Company, Milwaukee, Wis.

THURSDAY, MAY 31.

Title to be announced later. David B. Rushmore, member A. I. E. E.; railway engineering department, General Electric Company, Schenectady, N. Y.

"Economies Derivable from the Use of Relatively Small Water Powers of Low Head in the Middle West," by Dugald C. Jackson, member A. I. E. E.; professor of electrical engineering, University of Wisconsin, Madison, Wis.

"Oscillations and Surges Against Ground in Alternating-Current Systems," by Charles P. Steinmetz, member A. I. E. E.; electrician, General Electric Company, Schenectady, N. Y.

"Relative Merits of Various Types of Booster Control," by Joseph Bijur, associate A. I. E. E.; president General Storage Battery Company, New York, and Lamar Lyndon, associate A. I. E. E.; consulting electrical engineer, New York.

"Safety Devices for Steam Engines, Turbines and Motors," by Charles M. Heminway, associate A. I. E. E.; treasurer and manager, Consolidated Engine Stop Company, New York.

Applications have been made to the principal passenger associations for reduced railroad rates for members and guests who attend this convention. The Western Passenger Association, the Trunk Line Passenger Association, and the Central Passenger Association will probably grant the rate of one and one-third fare for the round trip on the certificate plan, which allows the holders of such certificates to purchase tickets for the return trip at one-third the regular fare, provided there are at least 100 certificates presented.

It is proposed by the United States Government to install and operate a submarine cable between Key West, Fla.; Guantanamo, Cuba, and the Panama Canal zone.

A Third-Rail Sleet Test

IN the March number of THE ELECTRICAL AGE an account was given of a test, conducted by the New York Central & Hudson River Railroad, to determine the effect of snow on the operation of electric locomotives when the third rail was protected in various ways. This test, it will be remembered, proved the superiority of the under-running type of third rail under such conditions.

A later test with different types of third-rail protection when subjected to the effects of a sleet storm in which the thickness of the sleet averaged about one-quarter of an inch, was also made. There were two types of over-running rails and three types of under-running rails tested.

Of the over-running rails, the unprotected type gave so much trouble that after three hours it was impossible to use them. The protected type of over-running rail had an inclined top, and on that side of the rail unprotected from the wind the sleet formed freely,—in some places so as to cover the entire top of the rail.

Of the under-running rails, those with wood protection had no sleet formed on them, the drip conveying the sleet off the edge of the covering. Those with mica compound insulation had no sleet formed on them except at the edges of the rail; and those with fibre protection had the drip carried off by the fibre, so that no sleet was formed on the contact surface.

The superiority of the under-running type of third rail, in comparision with the over-running type, was, therefore, as evident when tested with sleet as it previously was shown to be when tested with snow.

Copper may be distilled at atmospheric pressure by heating small pieces of the metal in a crucible in an electric furnace, the roof of which is perforated by a hole, covered with a thin glass bell-jar, while a copper pipe, through which flows cold water, traverses the furnace a few centimeters above the crucible and arc. It has been found by M. Moissan that the metal condenses on the tube to a depth of 5.7 mm. in the form of copper threads, resembling filamentous silver, the colour varying from red to yellow. It contains 99.76 per cent. copper, with traces of chalk and graphite, and after removal of the chalk by treatment with acetic acid, has a density of 8.16, which is lower than that of fused copper, and points to the occlusion of a small quantity of gas.

From Naples to Vesuvius

By FRANK C. PERKINS

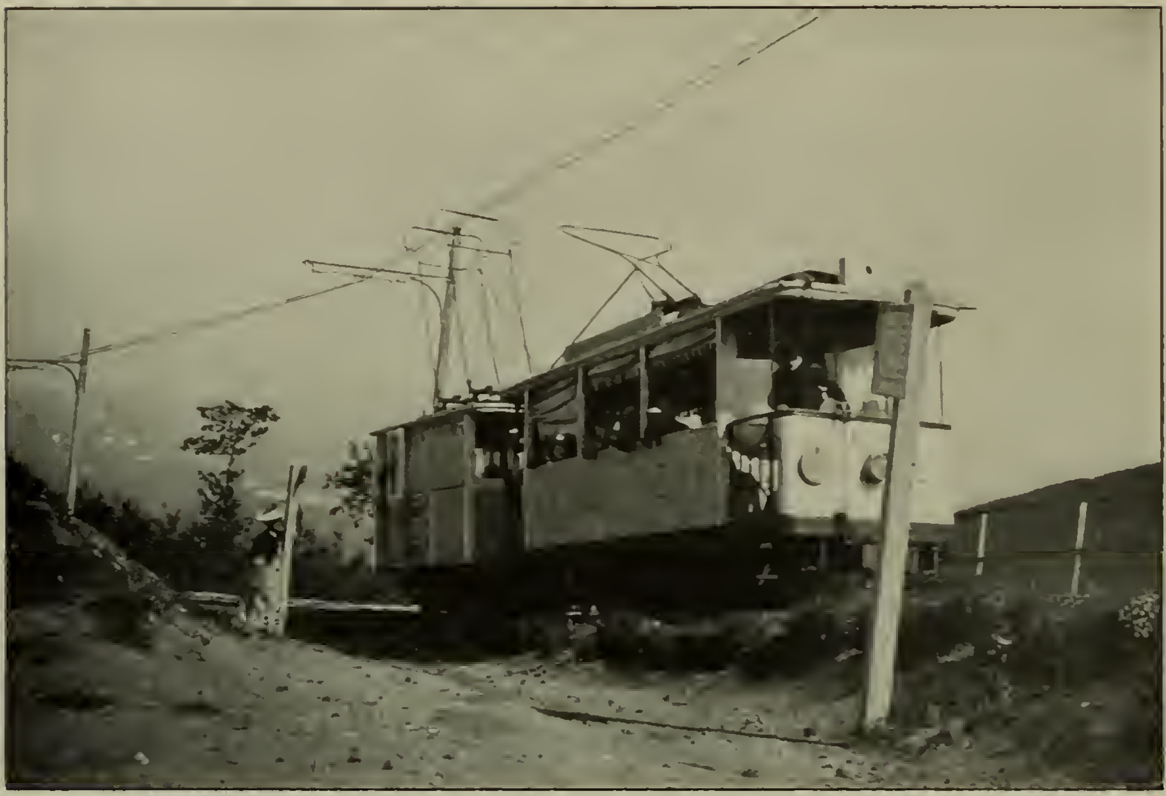
The recent eruption of Vesuvius has called attention to some of the difficulties of operating the electric road up the mountain. The lava flowing from the crater has damaged the line several times, and the eruption in April threatened at one time to wipe it out entirely. The uppermost, or cable, section suffered the most, but the work of reconstruction is now well under way.—THE EDITOR.

IN going from Naples to Vesuvius, the tourist makes the trip on the electric street railway and the suburban lines running through the towns of Aversa, Casoria, Capodichino, and Afragola. The overhead trolley, with the single pole and trolley wheel, similar to those on American railways, is used, although the cars are constructed on somewhat different lines.

At Capodichino and St. Pietro, steel side poles are used with arms and brackets supporting the trolley wire, while wooden poles are employed quite extensively at Afragola and elsewhere. The latest types of iron and steel poles are also used on a part of these lines with systems which are thoroughly up to date. The trains of the Naples suburban electric railways are usually made up of one motor car and trailer, or an electric locomotive and two trailers.

The power house of the electric railways of Naples is constructed of brick and stone, and is equipped with direct and alternating-current apparatus. Three horizontal, tandem-compound engines are each directly connected to electric generators, additional fly-wheels being provided for aiding the regulation. One of the generators is a six-pole, direct-current machine, while the remaining two are alternators of the revolving-

THE POWER HOUSE SUPPLYING CURRENT TO THE SUBURBAN ELECTRIC RAILWAYS OF NAPLES



AN ELECTRIC LOCOMOTIVE AND ELECTRIC PASSENGER CAR ON THE RACK SECTION OF THE VESUVIUS RAILWAY

field type. The engine and generator room is served by an overhead travelling crane of a capacity of something more than 11 tons.

The direct-current machines supply the trolley lines direct, while the alternators furnish current to substations, where rotary converters are used to supply direct current.

During the three months previous to the eruption in April, the volcano was very active, making it almost impossible to visit the crater, and several serious eruptions occurred during the past six months, the lava destroying a portion of the Mt. Vesuvius Electric Railway. Work was immediately begun to repair it, however, even while the lava was still running down the side of the mountain, as shown in the illustration on page 363.

When the wind was in the right direction, one could observe the action of the crater. From January 1 the activity of the volcano increased largely, and the ascent of the remaining 250 yards to the crater from the upper station of the electrically-operated wire rope section of the railway was seldom encouraged by the guides. A cable road was first constructed about two decades ago for the highest portion of what now forms the upper section of the Mt. Vesuvius Electric Railway. The cable drivers were driven by steam engines at first, but these are now superceded by electric motors.

Three different systems of electric traction are employed in conveying the tourist from Naples to the crater of the volcano. As far as Pugliano, the journey is taken by means of the ordinary electric cars or trams used in Italian cities; and from this point to the top of Vesuvius, one portion is of rack-and-pinion construction, another is of ordinary adhesion type, while the last section, which passes up the steep side of lava deposit to a point 3800 feet above sea-level, is the cable road.

The electric line from Naples is through the Strada di Chiaja, showing the Italian city street life as well as that of the suburbs, and gives one a fine view of the Bay of Naples. In the northern quarter of Resina, it runs through a most interesting cultivated section, with vineyards, orchards, and gardens on every side, to the Royal Observatory, which is nearly 2000 feet above sea-level. On the last portion of this section, where the train ascends the slope of Monte Cateroni, an electric locomotive is required for pushing the electric cars up the rack railway from the generating station at the foot of Monte Cateroni.

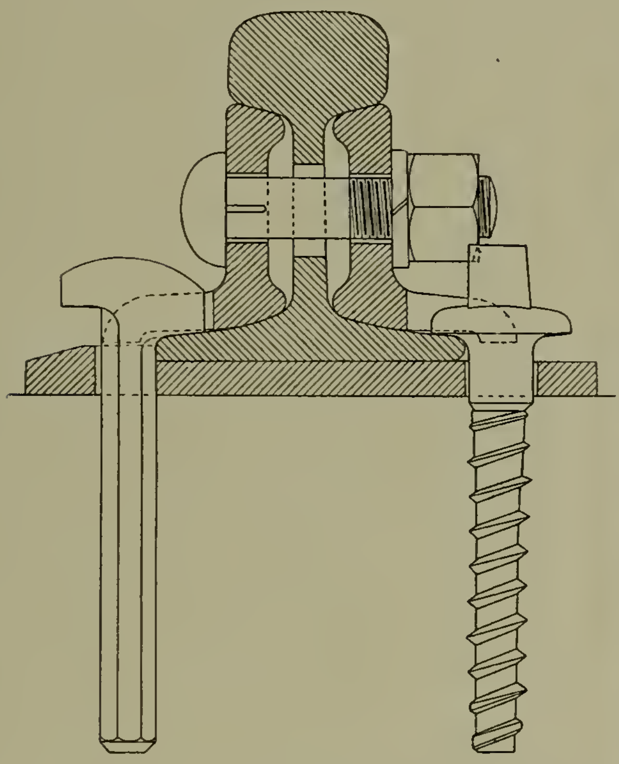
The track construction is similar to that of the Jungfrau Electric Railway. At a point 2600 feet above sea-level, the cable line begins and before the recent eruption destroyed a part of it, rose to a height of 3875 feet, with grades varying from 35 to 65 per cent. The cable cars each carry 21 persons. It is estimated that about 15,000 persons are carried to the top of this cable line each year, the larger numbers during the months of

A VIEW IN CASORIA, ONE OF THE TOWNS NEAR NAPLES

March and April, the average being for these months more than 2000 passengers.

On this trip, as soon as the station called the "Hermitage" is reached, the electric locomotive is removed, as this is the end of the rack section. The electric cars then haul the trailer by their own power past the Royal Observatory to the foot of the cone, where the funicular railway station is located. Only a few minutes were required for passing up the cable road to within a few hundred feet of the crater, which was finally reached on foot. Dark brown lava is noted on every side, frequently coloured pink and green by the rays of the sun. The great cone of ashes is seen above the mountain of lava, over which rises a black column of smoke. The fields of lava spread out in most curious and fantastic formations.

The Mt. Vesuvius Electric Railway, operating between Pugliano and the lower station of the cable road, has an electric generating station provided at the foot of the rack-and-pinion section, about 800 feet above the sea-level. The power station is provided with two gas engines, constructed by the Schweizerischen Lokomotiv-und Maschinenfabrik, of Winterthur, Switzerland. Each of these engines has a normal capacity



A SECTION OF THE RAIL ON THE VESUVIUS ELECTRIC RAILWAY

of 90 H. P., and operates a direct-current shunt dynamo at a speed of 700 revolutions per minute. The generators were designed for a maximum pressure of 770 volts, and supply a maximum of 137 amperes at a normal pressure of 550 volts. They also supply current to a storage battery of 300 cells, which is used for taking care of the peak of the load and also for regulation.

The electric locomotives used on the rack railway, and the overhead

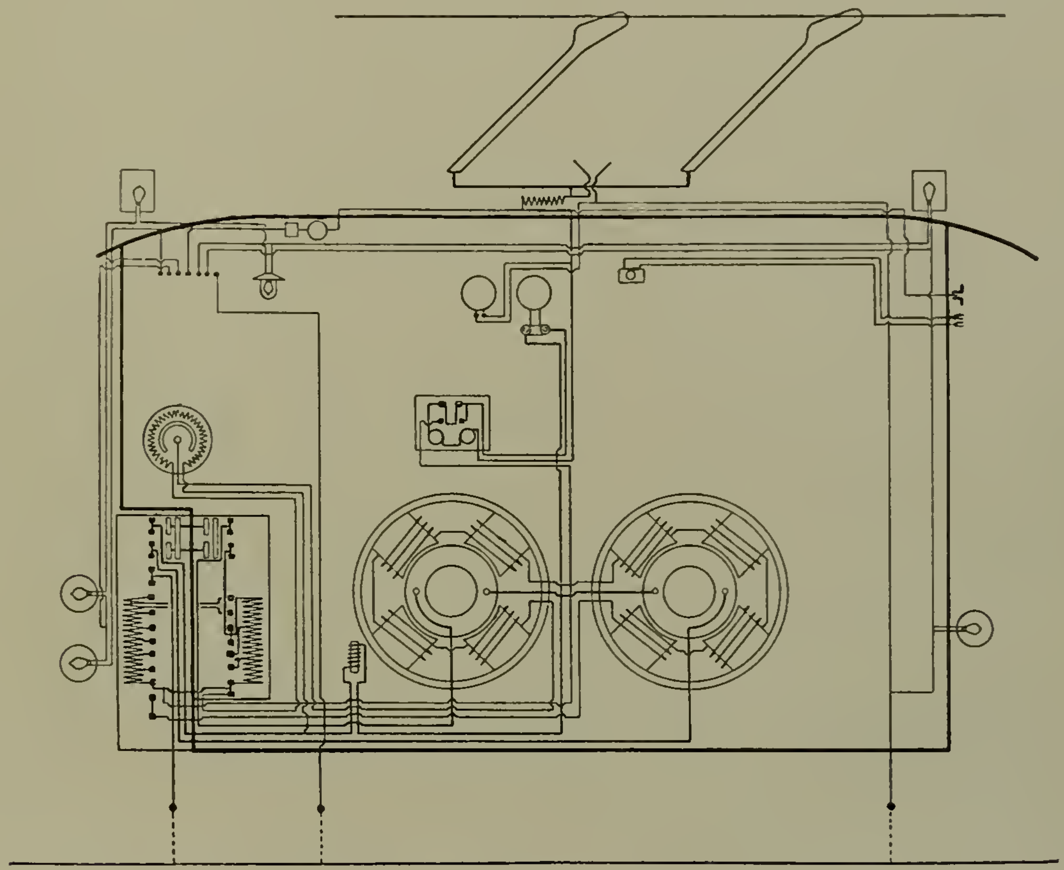


DIAGRAM SHOWING THE EQUIPMENT OF A LOCOMOTIVE USED ON THE VESUVIUS ELECTRIC RAILWAY

RECONSTRUCTING A PART OF THE VESUVIUS ELECTRIC RAILWAY DESTROYED DURING THE ERUPTION OF JANUARY. THE VAPOUR IS FROM THE HOT LAVA

A PART OF THE ELECTRIC RAILWAY ON VESUVIUS. AT THE RIGHT IS SHOWN A WALL BUILT TO PROTECT THE LINE FROM MOLTEN LAVA

THE LOWER STATION OF THE CABLE SECTION OF THE VESUVIUS RAILWAY

electric construction of the Mt. Vesuvius Railway were supplied by the Aktien Gesellschaft, Brown, Boveri & Co., of Baden, Switzerland.

The electric locomotive is provided with two motors, each having a capacity of 35 H. P., and operating at a speed of 700 revolutions per minute. The rack locomotive weighs somewhat over 10 tons, and operates at a speed of from $3\frac{1}{2}$ to 5 miles per hour, drawing a load of more than 10 tons. The locomotive is provided with emergency as well as hand brakes, together with automatic brakes, which are so arranged that the current is also shut off when the speed exceeds a certain limit.

The electric cars each weigh somewhat less than 9 tons, and are provided with single trucks having two axles. Three compartments are provided for each car, which seats eight passengers.

It may be stated that the rack-and-pinion section of the road has much higher grades than the adhesion section, the latter not exceeding 8 per cent., while the maximum for the former is about 25 per cent. The rails are fastened to wooden ties, the gauge being about 40 inches. The rack rail is located in the centre between the running rails. The total length of the electrically-operated sections is nearly five miles, and the trip over these portions of the road under ordinary circumstances takes about 50 minutes.

The total cost of the Mt. Vesuvius Electric Railway, including the cars, track construction, and power house, was about $250,000, or somewhat over $50,000 per mile. The cost of repairs is very high, especially on the upper section of this railway, where deposits of lava have given considerable trouble.

The central power station was constructed so that the capacity could be increased by installing an additional gas engine and generator. The engine room measures 55 feet in length and 47 feet in width, and the gas generator room measures 33 feet in width and 47 feet in length. A car barn has been provided in the same building for the electric locomotive and motor cars, with a capacity for six cars.

Canada has 793 miles of electric railways, with a capitalization of $61,033,321. In 1905, the gross earnings were $9,357,125; the operating expenses, $5,918,194, and the net earnings, $3,438,931. The passengers carried were 203,677,317, a gain of 2,777,319 over the preceding year. The freight handled was 510,350 tons, a gain of 110,189 tons.

Electricity in Sea-Coast Defense

ELECTRICITY has become of vital importance to an efficient system of gun defense, says the report of the National Coast Defense Board recently submitted to Congress. Of the $74,000,000 estimated as the cost of completing the coast defenses of the United States and the Insular possessions, $27,000,000 are for electrical equipment. This is divided as follows:—Power plants, including buildings, $6,250,000; submarine mine material, cable and the like, $5,650,000; searchlights, $3,486,000; fire control apparatus, cable, telephones, and the like, $11,793,000.

The following recommendations were made by the committee having this matter in charge:—

1. That the electrical power for fortification and defense purposes be furnished by a steam-driven, direct-current central power plant.

2. That each battery, or group of batteries, depending upon local conditions, be equipped with direct-current generators, gas or oil-engine-driven, installed as a reserve to the central plant.

3. That searchlights, except such as are in close proximity to the central plant, be provided with and operated by self-contained units.

4. That the torpedo casemates be equipped as heretofore with independent power for submarine mine purposes, as an integral part of the submarine mine defense.

5. That when alternating currents are essential, they should be obtained, if practicable, from direct current by means of a suitable converter; or, if more economical, by a separate alternating unit.

6. That the current from the fortification central plants, when not needed for fortification service, may be used for garrison purposes when such distribution does not require too large an increase in the size and number of units.

7. That if garrison service requires alternating current, this should be supplied by the central plant, either through a suitable converter or from alternating-current units specially installed for the purpose in the central station; such increase, however, and all additional cost due to post lighting being a charge against the proper appropriation.

8. That uniformity of types and accessories is desirable.

9. That all electrical power plants for the use of the fortifications shall be operated by the artillery.

The necessity for a rapid and efficient system of fire control and direction will be realized when it is considered that before the range is changed after an unsuccessful shot, the vessel fired on may be out of range. Hence electricity is largely responsible for the effectiveness of the armament, and the efficiency of the system has also resulted in a decrease of the number of guns necessary.

Electric Lighting in New York State

ACCORDING to a recent report of the New York State Commission of Gas and Electricity, in New York State there are 156 electricity supply companies, 50 gas and electric companies, 32 individual and 30 municipal electric plants. Of the 156 electric companies, only 34 pay dividends, and of the 50 gas and electric companies, only 14 pay dividends. Of the 51 coal and water gas companies reported, however, only 8 are paying dividends.

Since 1900, the number of enclosed arc lamps for public lighting have more than doubled, from 10,720 in that year to 23,226 at present. Open arc lamps for public lighting have decreased from 19,888 to 9298.

New York City has 77 per cent. of the number of commercial incandescent lamps in the entire State supplied by the purely electric companies, the capitalization of which is 71 per cent. of that of this class in the entire State. This city has also nearly one-half of the public enclosed arc lamps, and 3250 open arcs, the total of the former being 24,051, and of the latter 10,269. The number of the other lamps used is as follows:—Commercial arc lamps, 47,312; public incandescents, 99,749; commercial incandescents, 4,149,142.

Water power is used to generate electric current to the amount of 125,000 H. P. Seven companies are thus developing power, and two other plants, now under way, will add 100,000 H. P. to the amount now developed.

The World's Copper Production in 1905

RETURNS from the copper-producing countries of the world show the output to have been larger during 1905 than during 1904. The output of Great Britain,—500 tons,—remained unaltered, and there was a slight decrease in the output of Italy, 3250 tons, as against 3335 tons, and in Russia, 10,000 tons, as against 10,700; but with these exceptions, and a falling off of a few tons in Germany, 21,000 tons, as against 21,045 in 1904, there were general increases. The greatest increase was in the United States, where the output increased from 362,739 tons in 1904 to 421,000 tons in 1905, the next largest increase being that of Mexico,—from 60,945 tons to 65,000. The total output was 723,550 tons, the largest known. In ten years the production has nearly doubled, and the increase last year was no less than 74,626 tons.

The increase in the consumption of the United States amounted to about 32,000 tons, or about 7000 in excess of the total increased output of the year; but the consumption of Europe, as shown by the statistics, was much smaller,—nearly 45,000 tons in Great Britain, Germany, and France.

Annual Meeting of the Technical Publicity Association

AT the second annual meeting and banquet of the Technical Publicity Association, held Thursday, April 5, at the Aldine Association, New York, the following officers were elected:—President, F. H. Gale, General Electric Company; first vice-president, H. M. Cleaver, Niles-Bement-Pond Company; second vice-president, C. B. Morse, Ingersoll-Rand Company; secretary, Rodman Gilder, Crocker-Wheeler Company; treasurer, H. M. Davis, Sprague Electric Company. The members of the executive committee are:—Robert L. Winkley, Pope Manufacturing Company, and G. M. Basford, American Locomotive Works. The members of the election committee are:—C. W. Beaver, Yale & Towne Manufacturing Company; Charles N. Manfred, H. W. Johns-Manville Company, and H. N. Kress, A. S. Cameron Steam Pump Works.

It is reported that experiments in the use of electricity to promote the growth of farm crops are being carried on in the county of Worcestershire, England. The electricity is discharged from overhead wires suspended 16 feet above the ground, from poles 100 yards apart. The current is generated by a dynamo driven by a 3 horse-power oil engine at the farm buildings, and is transformed to a high pressure and distributed over the wires, the current going to earth through the air, and consequently through the crop that is growing beneath the wires thus placed.

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Leading Articles

Proposed Amendments to the Constitution of the American Institute of Electrical Engineers

QUITE a large number of proposed amendments to the constitution of the American Institute of Electrical Engineers, prepared by a special law committee and approved by the board of directors, have been submitted to its membership, to be balloted upon as a whole. Some of these amendments are of considerable importance; others relate merely to clerical changes in the wording of the present constitution.

Among some of the more important proposed amendments are those which relate to changes in the qualifications for transfers to full membership; the increase of the entrance fee from $5 to $10, and of the transfer fee from $10 to $15; the change in the date of the annual meeting and of the election of officers; and the proposed amendment to the present method of obtaining amendments to the constitution.

It is perhaps to be regretted that in this case all the proposed amendments have to be acted on as a whole, either for or against. There is no doubt that, at least, there appears to be no good reason why such of the proposed amendments as relate to improvements in the phraseology of the existing constitution should not be acted upon favourably. But, on the other hand, there is good ground for a difference of opinion as to the advisability, at present, of some of the more important amendments.

For instance, it is probable that many associates may object to the clause increasing the fee for transfer to the grade of member. As the total number of associates transferred to this grade annually is comparatively small, the gain in revenue may be neglected. It is somewhat difficult to imagine any other reason for the proposed increase, it being generally admitted that the technical requirements for transfer are ample.

It is also probable that the amendment relative to the technical requirements for transfer to the grade of member which would admit to membership a duly qualified engineer in an allied branch of engineering on more favourable conditions than an associate who is engaged exclusively as an electrical engineer, will meet with serious opposition. This clause, which provides that such a duly qualified engineer shall be eligible for transfer to the grade of member after two years of electrical engineering work, was doubtless instigated by a desire to meet the cases of mechanical or civil engineers who have drifted into the charge of electrical engineering work.

If the present standard of membership in the Institute, which is admittedly high and consequently the more prized, is to be maintained, there does not appear to be any valid reason why such engineers might not wait until they had acquired the minimum of four years' active practice of electrical engineering required by the present constitution.

Inasmuch as experience has shown that the plan now prevalent of electing the officers of the Institute in May is not satisfactory, there would doubtless be little, if any, objection to the proposition to change the date of election and of the annual meeting to January.

The present constitution requires that an affirmative vote of a majority of the qualified members and associates shall be necessary to secure the adoption of an amendment. The proposition submitted by the law committee of the Institute, whereby a quorum consists of 200 members and associates at the annual meeting, present in person or by proxy, is a swing of the pendulum to the other side, and will doubtless fail of approval by reason of the preponderance of influence it would give to the New York section, in which the annual meeting is held.

In fact, the framers of the present constitution probably builded better than they knew when they introduced and succeeded in having the existing requirements for amendments to the constitution adopted. If every vote that will be cast relative to the proposed amendments is in favour of the amendments, it is a question, in view of the proverbial lethargy of large bodies, whether the number of votes so cast will constitute a majority of the entire membership. With the votes that it is reasonable to expect will be cast against the amendments, it will be indeed remarkable if such a majority is obtained.

Perhaps it would have been better if the advocates of changes in the constitution had first instituted a successful propaganda for an amendment that would be less difficult of attainment than apparently is the present section relating to amendments to the constitution.

Tantalum Lamps for Street Lightning

ELECTRIC street lighting would be greatly strengthened in its competition with mantle gas burners by the use of low-voltage tantalum lamps. At present, electric street lighting with incandescent lamps is being rather hard pushed by the mantle gas burners that consume 3 cubic feet of gas per hour and yield about 50 mean horizontal candle-power each.

While these gas burners are distinctly inferior to electric arc lamps in streets where a high degree of general illuminations is required, they are a fairly acceptable substitute for 50-candle-power incandescent lamps, on the streets where only a moderate illumination is wanted, when the gas service offers any material reduction in cost. Unfortunately for electric street lighting, the mantle burner does offer a reduction in the cost of street lighting, as compared with carbon filament incandescent lamps, at the going rates for gas and electric energy.

Incandescent electric lamps for street lighting are operated in the great majority of cases on series circuits, because of the saving in weight of conductors on this system, and the lamps are regularly made with an efficiency of 3.5 or 4 watts per candle-power.

A 50-candle-power incandescent lamp thus takes 175 watts at best, and at the low rate of 4 cents per kilowatt-hour, the cost of operation for this lamp is thus 0.7 cent per hour, or $28 per year of 4000 hours, which corresponds to all-night and every-night service in street lighting. In contrast with this rate, the cost of gas to operate a 50-candle-power mantle burner, using 3 cubic feet per hour, is only 0.3 cent hourly, or $12 per year of 4000 hours. No doubt some part of the difference of $14 in favour of the mantle burner, at these rates, is offset by the cost of cleaning and lighting it, but a substantial profit probably remains.

To meet these conditions and turn the scales in favour of electric lighting, a low-voltage incandescent lamp with a tantalum filament is well adapted. Such a lamp could probably be given an initial efficiency of 1.5 watts per candle-power, without any undesirable reduction of its life, since the 110-volt lamps, as regularly made in Germany, have an initial efficiency of 1.7 watts per candle-power. At this efficiency, the 50-candle-power tantalum lamp would take 75 watts, and at the rate of 4 cents per kilowatt-hour, its operation would cost only 0.3 cent hourly, or $12 per year of 4000 hours.

This is just the cost of gas at $1 per 1000 feet, for the mantle burner during the same time, and the tantalum lamp has the advantage of a decidedly better quality of light without the expense of daily cleaning and lighting. For series distribution, the tantalum lamp of 50-candle-power, on a consumption of 75 watts, might properly be made to operate with 25 volts and 3 amperes, so that 120 of these lamps in series might be carried on a circuit at sufficient above 3000 volts to overcome the line resistance.

On a circuit of the same voltage, only 51 of the 50-candle-power, 175-watt lamps can be operated with a current of 3 amperes, because each of these lamps requires 58.3 volts. For a circuit of any other number of volts and amperes, the proportionate advantage of tantalum lamps would be the same, and a material saving in the cost of line conductors would result.

Another advantage of these tantalum lamps would be the increase of 133 per cent. in the number and candle-power of units that could be operated by transformers, generators, engines and boilers of given capacity.

One objection to series incandescent lighting has been due to the fact that the carbon filament falls rapidly in efficiency when subjected to the more or less fluctuating current of a series circuit. Tantalum is said to be free in large part from this defect. Another objection to series incandescent lamps with carbon filaments is the short lengths that these filaments must have to compensate for the low voltage at which they individually operate. Here, again, tantalum offers better conditions, because of its lower specific resistance, which is 0.830 ohm for a wire 1 meter long and 1 square millimeter in cross section, at the temperature corresponding to an efficiency of 1½ watts per candle-power in the filament of a lamp.

As made in Germany, the 110-volt tantalum lamp of 22 candle-power, and an initial efficiency of 1.7 watts per candle, has a filament 25.6 inches long and about 1.97 mils in diameter, with a weight of 0.022 gram. One ounce avoirdupois of tantalum is thus sufficient to make 1288 of these filaments. The price of this lamp is said to be $1 in Germany, but a lamp intended to operate at only 25 volts and taking 3 amperes would be much easier to manufacture, and would perhaps sell at a lower price, as the tantalum itself can hardly form more than a small part of the lamp cost. When such a lamp is available, electric street lighting with incandescent lamps will be much extended.

Telephone and Telegraph Supervision

STATE supervision of telephone and telegraph companies has been thoroughly discussed of late before the Massachusetts Legislature. In the light of the arguments presented, there seems to be little reason for applying commission rule to commercial signaling companies after the manner of regulating railroad, gas, and electric light corporations. These are the days in which every kind of public service work is obliged to pass under the lens of popular investigation. While there is no doubt that in many quarters publicity and legalized supervision are operating to correct abuses, it is difficult to see wherein the business of transmitting intelligence by electricity can be benefited, or the rates and service improved through the establishment of any State telephone and telegraph commission.

In the absence of any distinct popular demand for legislation, it is generally conceded to be good practice to avoid placing laws upon the statute books which may lead to unnecessary expense and unforeseen complications. The hearings recently closed at Boston on the proposed bill to place the telephone and telegraph companies under the supervision of the Massachusetts Highway Commission, brought forth no public demand whatever for the regulation of telegraph companies. Very little sign was shown that, as a whole, the subscribers of telephone service are not pretty well satisfied with the situation as it obtains in New England to-day.

The commercial signaling companies occupy a very different field from the transportation and power companies, although electricity is utilized in some form or other in almost every public service corporation's work, with the exception of the gas industry. There is no question of public safety in the use of the telegraph and practically none in the use of the telephone. Telephone and telegraph lines introduce no danger-

ous currents and do not in any real sense obstruct the public highways. The matter of public safety occupies an important place in the work of a railroad commission, and is not without significance in the supervision of the gas and electric light business but there is no ground for the establishment of a telephone or telegraph commission on this basis.

Rates and service are the essential points to be covered in the public supervision of companies transmitting intelligence. It is a grave question if any State commission would have the power to alter the rates of any company in so far as those rates related to inter-State business. In Massachusetts, 85 per cent. of the business of the Western Union Telegraph Company is of an inter-State character; the cable companies receive and send messages over foreign lines, and the wireless telegraph, the independent and the Bell telephone companies are by no means limited to an intra-State traffic.

Recommendations of rate charges might be made, but in view of the voluntary reductions made by the companies in the last two or three decades it would seem that there is little real basis for dissatisfaction. In 1866, the average tolls received per message by the Western Union Telegraph Company were 100.4 cents; in 1905 the average had fallen to 31 cents. The cost per message had fallen from 63.4 cents to 27.3 cents in this period, the result being a much smaller margin above operating expenses in the latter year.

Ten years ago the average exchange rental received per telephone by the New England Telephone & Telegraph Company was $83; last year this had been reduced to $38, all voluntarily in the interests of good business. The enormous increase in subscribers and enhanced valuation of the service which resulted from these and toll-rate reductions, is the logical outcome of the far-sighted policy adopted. The service has been extended and improved, the telephone company only striving to pay the reasonable dividend of 6 per cent. on its stock and to maintain the integrity of its investment against depreciation and the emergencies common to the business of operating thousands of miles of wire in exposed territory and in all the varied weather conditions of the New England climate. A single storm can easily wipe out the surplus above dividends and depreciation charges.

It is very probable that the telephone companies would not oppose State supervision by a commission if there were any considerable desire for it on the part of the public or any reasonable probability that the cost of maintaining such a body would be worth the expense. The annual reports of the telegraph and telephone companies are freely available to the public. The capitalization, volume of traffic, dividends, operating expenses, and the like, are all plainly set forth, and there is certainly little reason for the companies to be obliged to incur the expense of submitting such reports to a commission in different form from the make-up approved by their own auditing departments.

Absolutely perfect service cannot be given, even at the request of a State commission, however desirous a company may be of handling its business without delay and error. The lasting prosperity of every public service corporation depends upon the square deal between the company and its customers, and no one realizes this better than a progressive manager. The burden of maintaining a State commission may fall largely upon the companies supervised, and in the face of taxes now paid, such a burden is no light addition to the total assessment.

A commission capable of dealing with the exceedingly intricate problems of telephone and telegraph rates and service, should comprise a membership on the individual salary basis of at least $4000 or $5000 a year, plus office and administration expenses. It is hard to see how less than $25,000 a year would be sufficient for such supervision, for the Massachusetts proposition to place the telephone and telegraph companies under the supervision of a non-technical body like the State Highway Commission, is little short of chimerical. The New England company alone pays over $400,000 a year in State and local taxes in Massachusetts, or $3 per subscriber.

Finally, there is the question of monopoly. With two competing telegraph companies and one Bell telephone company in Massachusetts, to say nothing of the independent telephone organizations, there would seem to be a choice of message transmission routes which would tend to stimulate good service better than any proposed State commission, which on every count appears to have no legitimate cause for creation.

The Manila Electric Railroad & Lighting Corporation, which operates all the electric railways in Manila, aggregating 40 miles of track, reports for the four weeks ending March 7, gross earnings of $37,025.

Report of the Niagara Falls Municipal Power Commission

In 1903, the Canadian municipalities of Toronto, London, Brantford, Guelph, Stratford, Woodstock, and Ingersoll, agreed to pay the cost of securing a report on the feasibility of generating electricity by Niagara power and distributing it. These cities appointed the Municipal Power Commission, which acted with the Hydro-Electric Commission appointed by the Ontario Government.

The commission recently reported that the plant would pay a profit of 1 per cent., as $4\frac{1}{2}$ per cent. of the money invested could be realized from the sale of power, while debentures necessary to install the plant and build transmission lines could be floated at $3\frac{1}{2}$ per cent. Power could be generated at the falls for $4.95 per H. P.

The report shows that the capital cost of a 30,000-H. P. plant and transmission lines would be $6,864,629; of a 60,000-H. P. plant, $9,354,611, and of 100,000, exclusive of the cost of transmission lines to eleven additional municipalities which could also be supplied with power, $11,909,100.

The annual cost to the municipalities of maintaining the above mentioned plants would, in providing sinking fund, interest, etc., be as follows:—30,000 H. P., $859,610; 60,000 H. P., $1,138,551; 100,000 H. P., $1,413,634.

The estimated rates for power, supplied 24 hours per day, vary from $21.97, $15.73, and $14.60 per H. P. for the three capacities of plant for Toronto, to $34.48, $21.05, and $17.53 for Woodstock. Estimated charges for arc lamps of 2000-candle-power vary from $42.02, $37.61, and $36.48 per H. P. in Toronto, to $72.58, $64.02, and $60.40 in Ingersoll. The charges for incandescent lamps vary from 7.41, 6.40, and 6.14 cents per kilowatt-hour in Toronto to 13.21, 11.12, and 10.23 cents in Ingersoll.

There are about 225,000 miles of cable in all at the bottom of the sea, representing $250,000,000, each line costing about $1000 a mile to make and lay. The average useful life of a cable nowadays is anything between thirty and forty years, according to circumstances. About 6,000,000 messages are conveyed by the world's cables throughout the year, or 15,000 a day, the working speed for any one cable being up to 100 words a minute under present conditions. About 90 per cent. of these are sent in code or cipher.

The Testing of Alternating-Current Generators Motors

By E. B. RAYMOND, Electrical Engineer, the General Electric Co.

ALTERNATING-CURRENT GENERATORS

AFTER the various parts of a generator have been produced in the different departments of a manufacturing company, it becomes necessary to assemble and test the complete machine, not only to prove that it will go together and operate without difficulties, but that the various electrical characteristics are in accordance with guarantees, if any have been given, or in accordance with the accepted standard held by that particular manufacturing company.

The mechanical and electrical characteristics of importance to a customer, and of course to a manufacturer, in an alternating-current generator consist of the following:—

1. Efficiency at all loads, and incidentally in connection with this, the various losses that make up the efficiency.

2. The regulation, both at 100 per cent. power factor and at other power factors, depending upon the kind of service for which the generator is to be used.

3. The temperatures of the various parts when operating under the conditions which may be met with when permanently installed.

4. The voltage and current necessary for the field when the ultimate temperature resulting from the quality of load requiring the greatest field excitation is reached.

5. A demonstration of the ability to withstand short-circuit upon the armature, the short-circuit to be applied close to the machine, and with the generator operating at normal voltage.

6. Wave shape of the machine when running at various loads and normal potential.

7. Insulation resistances of all windings.

8. Ability to withstand not only normal potentials in the windings, but higher potentials applied with the machine hot, to demonstrate the factor of safety of this feature.

9. Noise of operation.

10. Quality of insulation used.

11. Method used to apply insulation and to wind coils.

12. Ability to withstand a certain percentage excess in speed.

13. Satisfactory operation of bearings.

14. Rotation of phase.

15. Satisfactory mechanical details of the various parts.

We will consider these various items in the order just given.

EFFICIENCY AT ALL LOADS—VARIOUS GENERATOR LOSSES

The efficiency of a generator is the ratio of the output in electrical energy to the input in mechanical energy. Thus, the output equals the input minus the losses. These losses consist of the following:—

Friction and windage.

Core loss.

I^2R loss in armature winding, where $I =$ current and $R =$ resistance.

I^2R' loss in field winding.

I^2R'' loss of brush contact.

Load losses.

To obtain the friction and windage and core loss, the best method is to belt to the alternator a direct-current motor. Connect an ammeter in the armature circuit of the motor and also one in the field circuit. Connect a voltmeter across its brushes. Then the input to the motor at any instant when driving the alternator, which equals volts across armature $\times$ amperes in armature, gives a measure of the energy represented by the friction and windage and core loss of the alternator, together with the friction, windage, I^2R loss, and core loss of the driving motor, plus the loss in the belt used in connecting the direct-current motor to the alternator.

The brushes on the commutator consume a certain amount of energy due to the I^2R loss of contact resistance. Since carbon brushes have a variable contact resistance, depending upon the current density, which is approximately equal to 0.025 ohm at 40 amperes per square inch, and 0.045 ohm at 10 amperes per square inch, it is best to have the driving motor equipped with copper brushes. The contact resistance of copper brushes being only one-tenth that of carbon, is so small that it can be neglected.

The driving motor should be of such a size that when driving its alternator at its normal speed and with the maximum field current at which core loss is desired, that it will be loaded only to about half load. This is so that no particular shifting of the brushes on the motor will then be necessary, for it is to keep the core loss of the driving motor constant throughout, so that when subtracting the motor input (which includes its own core loss) with field off the alternator, from its input with field on the alternator, the core loss of the driving motor being the same in each case will disappear in the calculation.

To this end, the field on the driving motor is kept perfectly constant throughout the core loss test by the ammeter in its circuit, and since the motor is so chosen in size that it is but half loaded, the armature reaction has no influence upon the actual field flux of the motor.

If the motor armature reaction were large and if it were necesary to shift the motor brushes during the test, then, although the motor field amperes were kept constant, an actual variation of motor flux, and hence of motor core loss, would result.

The motor being chosen and equipped as described, a voltage V is applied to its armature so that the alternator at any given field excitation will run at normal speed. At this alternator field excitation, let the amperes in the driving motor $=$ I. Let the armature resistance of the motor armature $=$ R, and the core loss and friction of the motor $=$ K′. Then IV $=$ the total watts input, and this includes the friction and windage of the alternator, which we will call F, its core loss which we will call K, and the loss in the belt, which we will call B. It also includes the core loss and friction of the driving motor, which we have called K′. Thus,

$$IV = F + K + B + K' + I^2R. \qquad (1)$$

The field current is next removed, and if there be observable any residual magnetism in the alternator, the

presence of which may be determined by a deflection in the voltmeter after the field current has been removed, it should be taken out by a slight touch of current through the field in the

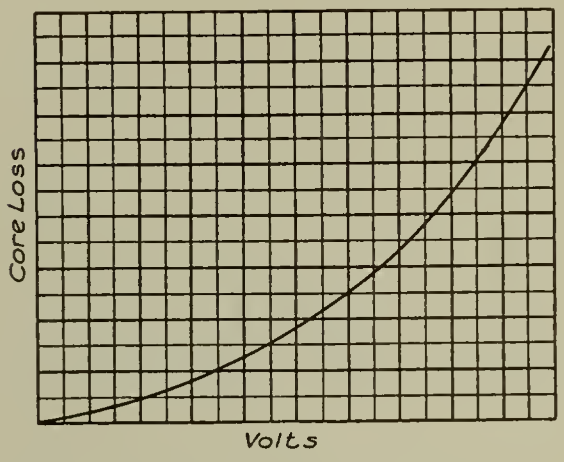


FIG. 1.—CORE LOSS CURVE OF AN ALTERNATING-CURRENT GENERATOR

opposite direction. The input measurement of the driving motor is then repeated, its field being kept perfectly constant as in the previous reading. The new input then is:—

$I'V' = F + B' + K' + (I')^2R.$ (2)

But B', the belt loss under the lighter load conditions, can properly be assumed the same as B under the load obtained with field on the alternator. If I^2R be calculated and subtracted from equation (1), and $(I')^2R$ be calculated and subtracted from equation (2), and if B' is assumed equal to B, we get from equation (1) the following:—

$IV = F + K + B + K'.$ (3)

Also, from equation (2):—

$I'V' = F + B + K'.$ (4)

Subtracting equation (4) from equation (3), we get $IV - I'V' = K$, or the core loss of the alternator.

If, now, we read the input to the driving motor with the belt removed, we get $I''V'' = K' + (I'')^2R$, and by calculating and subtracting $(I'')^2R$ from this we have:—

$I''V'' = K'.$ (5)

Subtracting equation (5) from equation (4), we get

$I'V' - I''V'' = F + B.$ (6)

Equation (6) gives the friction of the alternator plus the belt friction and the extra bearing loss due to belt tension. Since the last named is negligible compared with the friction of the alternator proper, equation (6) gives a measure of the friction of the alternator. We thus have determined both the friction and the core loss. This process can be repeated for the full range of field values of the alternator and a core loss can be obtained and plotted. It appears as shown in Fig. 1.

In obtaining a core loss as described, care must be taken before actually reading the input to be sure all acceleration and retardation have ceased, since these would alter the true input as recorded by the volts and amperes to the motor. A constant source of energy, therefore, is needed. The volts V on the motor with field on the alternator should differ from the volts V' and V'' only by the difference in the the IR drop in the driving motor armature; otherwise a flux variation is going on in the motor, and the results are incorrect.

The $(I'')^2R''$ loss in the armature can next be calculated by measuring the armature resistance when the machine is at normal running temperature, and knowing I'', the current corresponding to the load at which point the efficiency is being calculated.

The $(I''')^2R'''$ loss in the field can next be calculated, knowing R''' of the field winding and I''', the field current. The latter value can be measured by actually loading the alternator with the desired kind and amount of load, or, better still, can be calculated as will be shown under the subject of regulation.

The $(I'''')^2R''''$ loss in brush contact can be calculated, knowing the

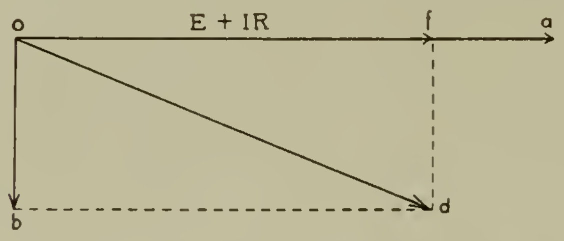


FIG. 2.—DIAGRAM SHOWING DIRECTION OF THE INDUCTIVE ELECTROMOTIVE FORCE WHEN THE ARMATURE CURRENT AND ELECTROMOTIVE FORCE ARE IN PHASE WITH EACH OTHER

field current and also that the contact resistance of carbon brushes on collector rings equals approximately 0.025 ohm at 40 amperes per square inch, approximately 0.038 at 20 amperes per square inch, and 0.045 at 10 amperes per square inch. If copper brushes are used, the brush contact resistance becomes negligible.

Now, as to the load losses. By "load losses" is meant the extra core loss due to the flow of current in the armature wires. This current induces in the neighbouring iron, in the teeth, and in the wire itself, eddy currents and local hysteresis, which increase with the amount of the current.

This loss is measured by short-circuiting the alternator upon itself through an ammeter. Enough field current is put on the alternator to cause a certain desired current to flow in the short-circuited armature. With this current held as desired by the field control, a complete core loss curve is obtained just as is shown in Fig. 1, only in this case the curve includes the various I^2R values. Since the value of R is known it can be subtracted, leaving the extra core loss due to the presence of the current in the armature wires.

To take this curve successfully, it is necessary to measure the resistance of the armature frequently, since the presence of the current tends to heat the armature and hence vary its resistance. Since the I^2R value is usually as great or greater than the short-circuited core loss itself, an error in the resistance R to be subtracted gives a large error in the result. It is customary to charge against the alternator 1-3 of this short-circuited core loss, since at best, measuring it as explained, with very low flux densities everywhere, a greater value undoubtedly results than when the alternator is actually operating with full flux in teeth, pole-pieces, and core. It may be regarded as a sort of semi-empirical value, more or less agreeing with actual conditions depending upon the details of design.

We know, now, all the losses, which are as follows:—

1. The open-circuited core loss taken from the core loss curve at a voltage point equal to $E + I''R''$.
2. One-third the short-circuited core loss taken from the short-circuited core loss curve at the desired current.
3. $(I'')^2R''$ of armature.
4. $(I''')^2R'''$ of field.
5. $(I'''')^2R''''$ of brush contact.
6. Friction and windage.

The efficiency can therefore be calculated by dividing the output by the output plus the sum of these losses.

REGULATION OF AN ALTERNATOR AT VARIOUS POWER FACTORS.

If an alternator is running at full load, and if this load be thrown off suddenly without allowing the speed of the alternator to vary, the volt-

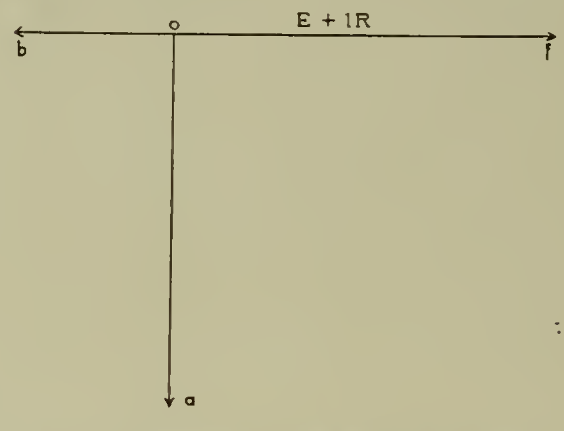


FIG. 3.—DIAGRAM SHOWING DIRECTION OF INDUCTIVE ELECTROMOTIVE FORCE WHEN THE ARMATURE CURRENT LAGS 90 DEGREES BEHIND THE ELECTROMOTIVE FORCE

age will rise to a value greater than before. This increase of voltage, divided by the normal voltage existing

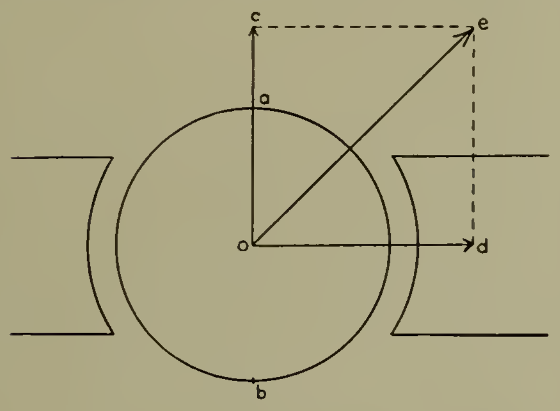


FIG. 4.—DIAGRAM SHOWING THE FIELD AMPERE-TURNS WHEN THE ARMATURE CURRENT AND ELECTROMOTIVE FORCE ARE IN PHASE WITH EACH OTHER

before the load was removed, is called the regulation of the alternator.

This rise of voltage can be directly measured if actual load can be placed upon the machine, and if means exist to keep the speed constant and at the desired amount. Under ordinary circumstances, however, these conditions do not exist. It then becomes necessary, and in fact is usually better, to take certain no-load readings from which can be accurately calculated the full-load

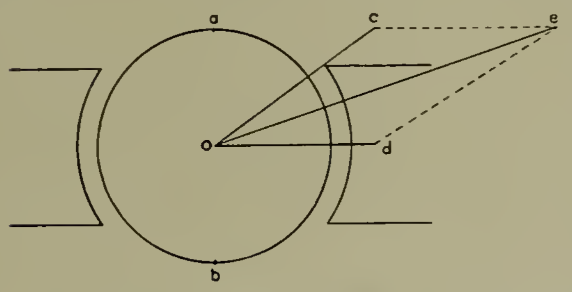


FIG. 5.—DIAGRAM SHOWING THE FIELD AMPERE-TURNS WHEN THE ARMATURE CURRENT LAGS BEHIND THE ELECTROMOTIVE FORCE

regulation at any desired power factor.

Let us consider then, what causes the voltage of an alternator to lower when the load comes on. First, there is, of course, the ohmic-resistance drop of the winding. Second, there is the inductance of the winding located in the slots, which is equal to

$$\frac{\text{flux} \times \text{turns}}{\text{amperes} \times 10^8}$$

When the flux is thus produced locally around the wire, its path is across the air gap, across the pole-face, back across the gap again, completing the circuit. This self-induction flux is, of course, an imaginary one, combining with the normal flux from the field winding, into the resultant flux, which actually flows through the coils of the armature, producing the total voltage E + IR, where R is the resistance of the armature, and I the current flowing. Thus, the core loss of an alternator giving the voltage E, corresponds to the flux necessary on no-load to produce the voltage E + IR.

The imaginary separate self-induction flux is in phase with the armature current, since all fluxes produced by current are equal in phase with their currents, and hence the electromotive force created by it is at right angles to the current. Thus, if the current of the armature is in phase with the electromotive force of the alternator, the electromotive force of self-induction would be combined at right angles with the electromotive force as shown in the diagram in Fig. 2.

In the diagram, *oa* equals the current, *of* equals E + IR, *ob* is the e. m. f. of self-induction, and *od* the resultant e. m. f.

If the current in the armature lagged 90 degrees behind the e. m. f., the diagram would appear as in Fig. 3. Here, as before, *ob* is drawn 90 degrees from the current *oa,* and *oa* is lagging 90 degrees behind the e. m. f. *of.* The e. m. f. of self-induction, *ob* exactly opposes, in this case, the external e. m. f.

Another cause of the voltage being lowered is armature reaction. This is a separate effect from the armature self-induction. Since current flows in the armature, the armature ampere-turns must act to create lines of force just as do the ampere-turns of the field. They are in the same magnetic circuit as are the field coils and must receive the same consideration. Thus, in every case for a given flux flowing through the armature and giving the voltage E + IR, the ampere-turns are the resultant of the field and armature ampere-turns.

Fig. 4 shows an alternator armature with the collector-rings tapped at *a* and *b.* The armature e. m. f. reaches a maximum at the position shown. If the current is in phase with the armature e. m. f., the current reaches a maximum at the same position. The direction of magnetic action is therefore in this case represented by *oc,* at right angles to the direction of magnetic action of the field ampere-turns, shown by *od.* The ampere-turns in the field required to overcome this are shown by the resultant *oe.*

If, now, the current lags somewhat behind the e. m. f., the diagram appears as in Fig. 5. Here *oc,* the vector representing the current, is lagging behind the e. m. f. *oa,* and the resulting ampere-turns in the field required to overcome this is represented by the line *oe,* which is larger than before.

With current lagging 90 degrees, the line *oc* would require additional ampere-turns in the field. Thus, as in self-induction, we have the armature ampere-turns acting at right angles at a non-inductive load and directly opposing at a 90-degree lagging load. On account of this similarity, C. P. Steinmetz has suggested combining the two effects, which he calls "synchronous impedance." This then becomes a value which can ac-

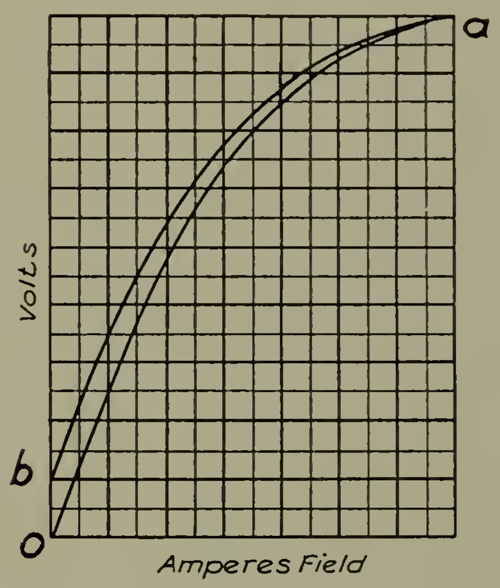


FIG. 6.—SATURATION CURVE OF AN ALTERNATOR

tually be measured upon any existing alternator. It is obtained as follows:—

The alternator is short-circuited upon itself through an ammeter, just as in the case of a short-circuited core loss. Enough field current is applied with the alternator running at normal speed to give any desired armature current, say a full-load current. Since the armature is more inductive than non-inductive, its current will lag practically 90 degrees behind the small induced electromotive force necessary to produce it on

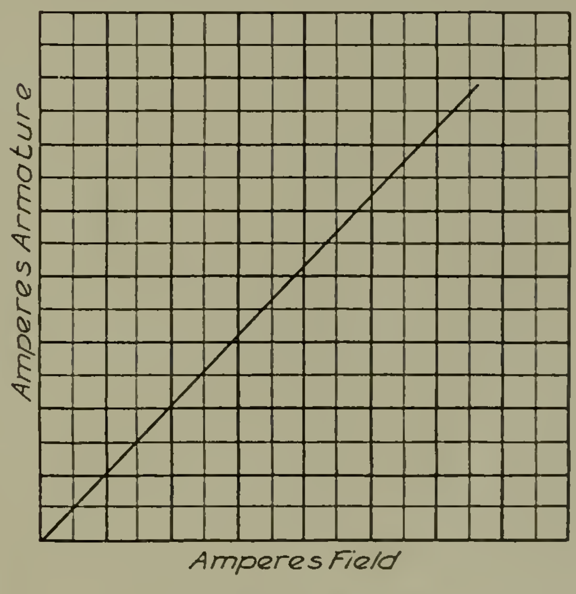


FIG. 7.—SYNCHRONOUS IMPEDANCE-CURVE OF AN ALTERNATOR

short circuit. Thus the armature ampere-turns, as well as self-induction, directly oppose the field ampere-turns, or using the new expression, the field ampere-turns are a direct measure of the synchronous impedance.

We have now found a way to get this important value. When plotted the curve looks like that shown in Fig. 7, from which the ampere-turns of the field can be found for any desired number of armature amperes.

The next procedure in obtaining the regulation of an alternator, having now obtained the synchronous impedance, is to combine with its ampere-turns for any load and electromotive forces the field ampere-turns to give the normal voltage plus IR. Hence, we wish a curve giving an open circuit and normal speed, the no-load terminal electromotive force plotted against the field ampere-turns. This curve is called a saturation curve and is shown in Fig. 6.

The curve is taken with the residual magnetism removed, and with various increasing values of field current, the volts across the armature are read up to the point *a*. From *a*, the field current is gradually reduced till the point *b* is reached. An average of the rising and falling values may be used in calculation, though as a matter of fact, these two curves are so near together that they are practically the same. The area *ob* represents the residual magnetism.

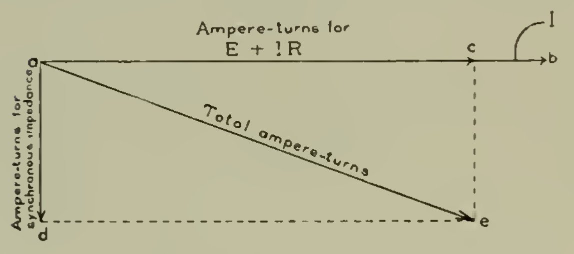


FIG. 8.—DIAGRAM SHOWING THE TOTAL AMPERE-TURNS REQUIRED BY THE ALTERNATOR FIELD ON A NON-INDUCTIVE LOAD

We now have at a given armature current the field ampere-turns for the synchronous impedance, and also for the no-load voltage plus IR. To obtain at this load the total ampere-turns actually required by the alternator field, these two values are combined just as in the case of any reactance and electromotive force. It must be remembered that the synchronous impedance must be plotted at right angles to the current. Thus on non-inductive load, the combination would be effected as in Fig. 8, giving the resultant ampere-turns equal to *ae*.

For a lagging load, the diagram would be as in Fig. 9. When, as shown, the current I, or *ab*, lags behind the e. m. f. *ac* by the angle *bac*, the line *ad*, as before, being the synchronous impedance plotted at right angles to the current *ab*. Thus the resultant ampere-turns necessary are shown by the line *ae*, which is the diagonal of the two sides *ac* and *ad*, as before. By trigonometry, the length of *ae*, in Fig. 9, can be shown to have the following value:—

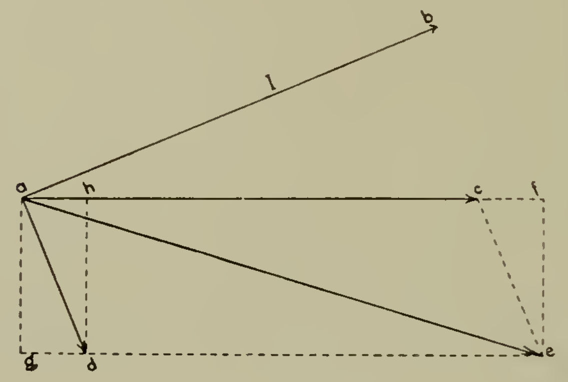


FIG. 9.—DIAGRAM SHOWING THE TOTAL AMPERE-TURNS REQUIRED BY THE ALTERNATOR FIELD ON AN INDUCTIVE LOAD

$$ae = \sqrt{[(I-4)\cos a]^2 + [(E+IR) + (I-4)\sin a]^2}$$

The values of all the quantities on the right-hand side of the equation are known.

For any power factor, therefore, we have a method of finding the necessary ampere-turns to give the load at that power factor. If this load is thrown off and the field current be kept as before, the voltage will rise. The amount of the rise can be found from the saturation curve of the alternator shown in Fig. 6. If this voltage as read from the saturation curve be represented by E′, and the terminal electromotive force at load by E, the regulation $= \frac{E' - E}{E}$

This method of no-load reading to calculate full-load regulation on ordinary normally designed commercial alternators, agrees exactly with the results obtained by throwing on and off load and observing the increase of voltage. It affords also an exact way of finding the regulation of an alternator of any size or phase without actually putting load upon it,—a very necessary method considering the enormous size of individual units now being produced.

From the calculation of regulation, two curves can be plotted; one called a compounding curve, which gives for various loads and at constant speed the ampere-turns of field necessary to keep the alternator at a given voltage, and the other a curve showing the variation of voltage at a constant speed as the load comes on. Both these curves can, without difficulty, be observed under actual running conditions if the necessary power, etc., is available.

The latter curve is of particular interest in showing how much the circuit voltage will be effected with varying load without field adjustment to keep the alternator at any desired voltage. The compounding curve of an alternator is shown in Fig. 10, and the drop of voltage curve or field characteristic is shown in Fig. 11.

TEMPERATURE MEASUREMENTS

To obtain the temperatures of the various parts of a small alternator when operating under the conditions which may be met when permanently installed, it is only necessary to drive the machine at normal speed and at desired load until the temperatures become constant. This time on a 10-KW. machine may be 3 hours, while on a 10,000-KW. machine it may be 18 hours. With a 10,000-KW. alternator it is not usually possible to obtain the necessary power to turn the machine at full load.

There are two good methods of getting the data without actually supplying load. One method is to run the alternator free with enough field excitation to produce a core loss equal to the normal core loss of the machine when running at normal voltage, that is, the core loss at E + IR voltage on the core-loss curve taken, as has been described, plus the I^2R loss of the windings. The core then has within it the normal losses, and will rise in temperature accordingly; that is, the I^2R loss in the field winding may not be the same as when running under actual load conditions, but the rise can be obtained under the test conditions, and knowing also from the regulation test, as described, the full-load field curve, the new field temperature can be calculated from the no-load temperature, since rise in temperature is directly proportional to the watts lost in the spool.

The error is that the distribution of these losses is not the same as when running under load, but in ordinarily-designed machines, very satisfactory results can be obtained by

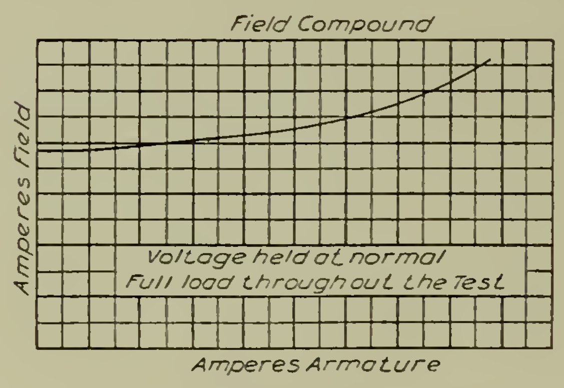


FIG. 10.—COMPOUNDING CURVE OF AN ALTERNATOR

this method, and its convenience and simplicity commend it.

Another method of obtaining normal full-load conditions in the core,

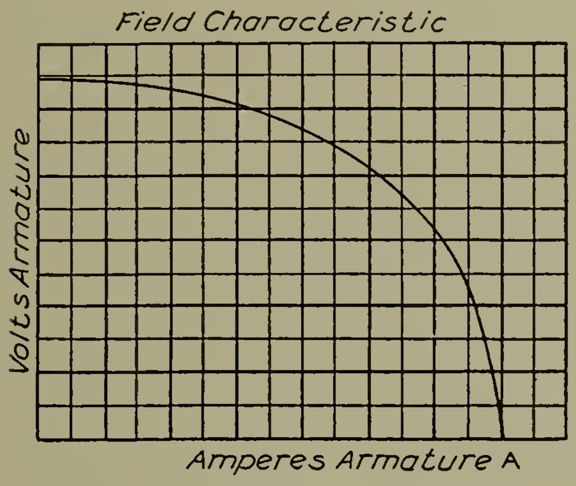


FIG. 11.—FIELD CHARACTERISTIC CURVE OF AN ALTERNATOR

is to oppose some spools to others and short-circuit the armature upon itself. If, for instance, an alternator having twenty poles, ten north and ten south, has them so connected that fourteen of them are north and six are south, and if full-field current be put upon the spools, there would be set up in the armature an electromotive force which would be the result of the free un-neutralized poles; in this case, eight poles would be left to produce electromotive force in the armature.

If, now, the synchronous impedance electromotive force taken as described with the armature short circuited, requires just this amount of electromotive force, we have a method of producing full-load current in the armature with full-load current in the field, and approximately normal core loss. Thus a certain number of poles are reversed against the others, the number being so chosen that the electromotive force resulting from their difference or resultant gives full-load current on the armature when it is short-circuited upon itself. Exact normal conditions are produced in this way, with the exception of the core loss.

It can be seen if one group of poles is reversed, that at the point of reversal two north poles will come together, and at the other end of the group two south poles. The percentage effect in an alternator of over ten poles is of small consequence, and for one of twenty poles entirely disappears. The method has the advantage of creating in the alternator normal stresses, for one part of the alternator acts as a motor under normal torque per pole, and the other part as a generator, so that pressure of coils against slots and end stresses exist during the run.

The method is extensively used by all manufacturers and gives accurate results. Knowing how to obtain regulation as has been described, the field current can be made to correspond to the load condition desired. The desired armature current is obtained by properly grouping the poles.

This method gives a measurement of field temperature and voltage under any of the desired load conditions, and thus covers the fourth item in the desired data. By means of the no-load open-circuit method, the field voltage for load condition may have to be calculated from the open-circuited test run condition. This, however, is a perfectly simple and accurate process.

ABILITY TO WITHSTAND SHORT-CIRCUIT.

Any alternator should be able to withstand a short-circuit between any or all of its circuits with full-field current held constant and with the location of the short-circuit close to the terminals of the machine. From an examination of Fig. 11 it will be seen that as the load increases the voltage falls until a point is reached where the voltage becomes zero, and the amperes a certain definite and final amount. Thus, when the alternator is short-circuited, the ultimate condition is at the point A, Fig. 11.

Before this point is reached, however, the jump of current in the armature when short-circuit first appears and before the voltage begins to fall, is very great and is held up by a current induced in the field by this armature current. This extra current in the field tends to stop the decline of the current in the armature down the curve as shown in Fig. 11. In fact, the decline of current follows the time constant of the field circuit.

Thus for several waves, depending upon the design of the alternator, there may be ten to fifty times normal current in both field and armature. Thus, there are enormous magnetic reactions, and unless the windings are well held and properly made, they will be forced out of their normal position and perhaps destroyed. All properly-made alternators should stand this test.

WAVE TEST AT NO LOAD AND FULL LOAD

This test is essential for many reasons. An alternator used for long-distance transmission and having a wave-shape departing seriously from a sine curve, has waves of higher frequency imposed upon the fundamental. This follows, because any wave is always the combination of one or more sine waves.

These waves of higher frequency acting upon the inductive and capacity of the line may create a semi-resonant condition giving results entirely different from those predicted for the fundamental. Also, such waves acting upon induction motors may lower their efficiency, since all electromotive forces may no longer be 120 degrees apart, and since in a delta-connected induction motor for three-phase circuits, any other applied electromotive force will produce local currents in the winding, lowering efficiency, power factor, etc.

One method of taking such waves is to have a sector or contact piece, which can be accurately located with reference to the poles of the alternator. A brush revolves, touching this thin contact once in a revolution. The electromotive force is between this brush and the contact. When they touch, the circuit is completed to a voltmeter with a small condenser in multiple with it. Thus, the instantaneous voltage corresponding to the sector position is read. If the contact segment is moved in accordance with a scale calibrated in degrees, the wave form can be read off.

An excellent method of recording the wave form is by means of photography as employed in the oscillograph. This apparatus has been described in the March number of THE ELECTRICAL AGE, and so needs no further mention here.

INSULATION RESISTANCE OF ALL WINDINGS

This can easily be obtained by connecting to a given voltage a voltmeter in series with the insulation resistance desired. For instance, if the insulation resistance of a spool is desired, a wire is connected to one side of, say, a 500-volt circuit and to one terminal of a voltmeter. From the other terminal of the voltmeter a wire is run to one terminal of the spool. From the iron on which the spool is assembled, i. e., the ground, a wire is run to the other side of the 500-volt circuit. Under these conditions the insulation resistance and the voltmeter are in series with each other and have applied to them the 500 volts.

Let $D =$ the deflection resulting from this connection; $X =$ the insulation resistance desired; $R =$ the resistance of the voltmeter; and $V =$ the voltage of the circuit. Then, since the voltage drop is propor-

tional to the resistance through which the current flows,

$$\frac{X}{R} = \frac{V-D}{D}, \text{ or } X = R\left(\frac{V}{D} - 1\right)$$

This measurement should be taken with the machine at normal running temperature.

ABILITY TO WITHSTAND A POTENTIAL GREATER THAN NORMAL

Of more importance than the insulation resistance is the ability of the windings to withstand from two to three times the electric stress to which they are ordinarily subjected in normal operation. It is proper to apply such a potential for one minute. For instance, a 500-volt railway generator ought to be able to withstand 3500 volts between windings and the iron of the machine for one minute with the machine at normal running temperature. An alternator of 2300 volts should withstand 9000 volts. The American Institute of Electrical Engineers has issued a formal statement of the best present practice regarding insulation tests. It is necessary to apply the potential when the machine is hot, as then the usual insulation is less able to withstand the strain.

NOISE OF OPERATION

For obvious reasons, the noise of operation is objectionable. A properly designed alternator need not make noise of any consequence. Noise may be due to loose laminations, in which event it is not objectionable, but the loose laminations may injure the machine since their movement may wear into the insulation or may break off the teeth of the core. To correct the trouble, the core must be stiffened up.

Noise may be due to excessive magnetic densities in the teeth, to a too sudden entrance of the teeth into the pole influence, or to mechanical puffs of air giving a whistling noise. The air and magnetic efforts usually produce similar sounds, so that rotating the armature at normal speed with field off must be tried to find the true cause.

QUALITY OF INSULATION USED

While this is not essentially a testing point, a purchaser ought to know the kind of insulation in his machine. Various insulating materials exist which may serve temporarily and be all right when cold, but only the properly made varnishes with linseed oil as base will be just as good at temperatures which an alternator may have to withstand, and will improve rather than grow worse with age. For windings designed to carry high potentials, a statement of the kind of insulation used should be a part of the acceptance test.

METHODS USED TO APPLY INSULATION AND TO WIND COILS

As the quality of insulation is important, so also are the methods of applying it and of winding the coils. Coils can be wound and insulated in the form in which they should be when applied to the alternator armature, and then located in their final position without hammering, or they can be only approximately formed and not wholly insulated, and then forced by pressure or hammering into their final position. The former method costs more, but leaves a coil in position with all its insulation perfect. The latter method is cheaper, and gives for the first test, perhaps, as good insulation resistance and ability to withstand the American Institute of Electrical Engineers' "high potential" test, but the life is not there, and at the end of twenty years the two machines are greatly different in value.

ABILITY TO STAND EXCESS OF SPEED

Since various conditions may arise where alternators may run up above normal speed, the complete test of a machine should include this performance. Many alternators which are to be connected to water-wheels are required to operate at double speed in case of a runaway due to governor troubles.

SATISFACTORY OPERATION OF BEARINGS

This is an essential feature in the satisfactory operation of a machine. Bearings should run with a rise in temperature of less than 40 degrees Centigrade; otherwise, extra heating, due to temporary dirt may run the temperature up to a point when the melting of babbit or cutting may occur with consequent need of an actual shut-down.

Bearings should not lead or throw oil.

Oil, particularly that of the cheaper varieties, eventually injures insulation. It permits the sticking of dirt to leakage surfaces, which when dry or clean should serve as insulation. The result is that in time a ground will occur and a short-circuit result. There is no excuse under any condition for the leaking or throwing of oil from a bearing.

ROTATION OF PHASE

A given induction motor should run in a certain definite direction when connected similarly to all alternators of a given company's make. Thus, such alternators, when connected in multiple a certain way, will go all right, and when an induction motor load is thrown from one alternator to another, a reversal of the motors will not occur. A testing room should, therefore, have a phase rotation "judge" applied to every alternator shipped. The "judge" consists of an induction motor always used for this purpose.

SATISFACTORY MECHANICAL DETAILS

The mechanical details are too many to be mentioned here, but such features as the following should all be examined and properly passed upon:—Ease of assembly, and ability to get at parts that might need repairs, size and uniformity of air gap, capacity of oil well for bearings, kind of oil rings, quality of material, arrangement for keeping the case tight, material used to insulate armature laminations from each other, pressure fits, size of shaft, mechanical holdings of spools, holding of coils in slots, free longitudinal motion, or end-play of shaft in bearings with and without field, "springing" of field with excess of magnetism, strength of fingers to hold teeth of armature tight, strength of core, and direction of air ventilating currents.

While this list of testing data of interest to a purchaser looks long on paper, it takes only a short time to obtain it in a testing room, and the money spent is a cheap insurance of future excellence of operation under all ordinary conditions for many years.

INDUCTION MOTORS

An induction motor field or stator is usually wound either three-phase or quarter-phase. The armature or rotor may be wound similarly, or may have no definite winding, consisting simply of single bars located in the slots and connected on the ends with a conducting ring.

The latter kind of winding is the well-known "squirrel-cage," and is used very extensively where an especially low starting current is not essential. It is a cheaper and more rugged form of winding, and, after the motor is once started, gives as excellent results as the direct-wound winding. This type has a starting resistance connected with it which is left in at starting and gradually cut out as the motor comes to synchronism.

The squirrel-cage type of motor is started with a compensator which gives a low voltage at the time of

starting, and then increases the voltage to normal after the speed increases to such a value that the back e. m. f. within the armature takes the place of the starting resistance. It is a fact that for a given weight of copper on the rotor it makes no material difference in regard to the characteristics of the motor, whether the winding is a direct phase winding, like the stator, or whether it is a squirrel-cage winding, and, therefore, the items mentioned below as necessary to have to properly understand a given motor apply both for the direct winding and for a squirrel-cage winding.

The only exception in the methods of test in the two cases is in the torque curves from rest to synchronism. With a direct winding with its starting resistance connected to it, the torque from rest to synchronism should be taken with the various resistances in circuit, and one of the resistances should be so chosen that the maximum torque would occur just at the starting point.

It is a fact that the insertion of resistance in a rotor of an induction motor has no influence on the maximum torque. It only regulates the drop in speed at which the maximum torque occurs. Therefore, a resistance may be chosen which will give the maximum starting torque at rest. In a squirrel-cage rotor having no starting resistance, the starting torque naturally will be low, as will the torque in the first part of the rise of speed toward synchronism, since without resistance the rotor current phase is lagging at starting, as then the rotor has within it full frequency and much more inductance than resistance. The low torque per ampere on the squirrel-cage at starting is made up by putting in more amperes, and these extra amperes required at starting by the squirrel-cage are obtained not directly from the line, but, as stated, through a compensator, which thus relieves the line (the ratio of the compensator is, perhaps, 2 to 1) from the large drain of current.

Thus, items 1 to 9, mentioned below, concerning induction motors, are required similarly for the direct-wound rotor as well as for the squirrel-cage winding. The currents in a properly constructed squirrel-cage circulate around in phase electrically, acting similarly to the currents in a direct winding.

The mechanical and electrical characteristics in an induction motor of importance to a customer, and of course to a manufacturer, are as follows:—

1. Efficiency at various loads.
2. Power factors at various loads.
3. Apparent efficiency at various loads.
4. Maximum output at normal voltage.
5. Current and torque at starting.
6. The "running light" current.
7. The torque from rest to synchronism.
8. Drop in speed at various loads.
9. Temperature of the various parts under normal load until constant temperature is reached; also temperature after overloads of certain amounts and after certain times.

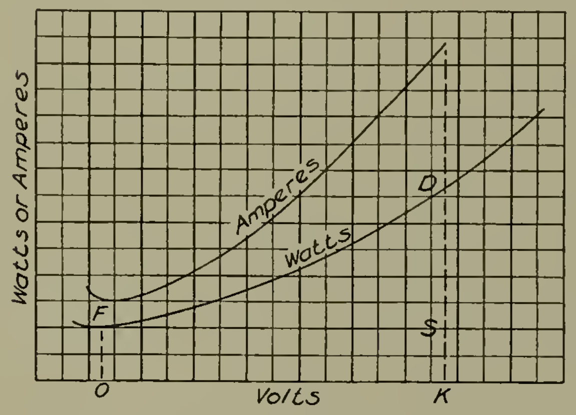


FIG. 12.—EXCITATION CURVES OF AN INDUCTION MOTOR.

Items 1 to 9 can be obtained by applying to the motor the well-known prony brake, reading the output with it and the input with wattmeters and ammeters. This prony brake for the torque readings should be not the ordinary one, but a revised Prony brake method should be used. The motor rests on a platform scale, and the change of its weight read as the pull from the torque occurs, gives a measure of the torque. Such an arrangement permits an accurate reading at any part of the curve from rest to synchronism, the man operating the brake holding the motor at any desired per cent. synchronism by the tension on the cord or tape around the pulley producing the torque. For the heat run it is more convenient to belt a D. C. generator as load, the energy going into a rheostat or being "pumped back" into the source of energy, similar to the "Hopkinson" method in D. C. apparatus. With a three-phase motor, two wattmeters are necessary, the current coil of No. 1 wattmeters being in line No. 1, the current coil of wattmeter No. 2 in line No. 2, the voltage coil of wattmeter No. 1 between line No. 1 and No. 3, and the voltage coil of wattmeter No. 2 between line No. 2 and line No. 3.

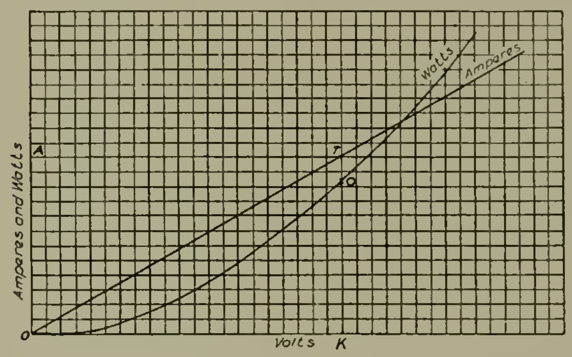


FIG. 13.—IMPEDANCE CURVES OF AN INDUCTION MOTOR.

The watts input equals the sum of the two wattmeter readings. It must be remembered, however, that under some conditions, if the lag of the current behind the e. m. f. is over 60 degrees, one wattmeter will read negative. The reason that the wattmeter reads negative is that the current, in line No. 1, for instance, if it were inductive, differs in phase from the voltage between 1-3 by 30 degrees, which is true of any three-phase circuit. If the current in line 1 commences to lag, the angle formed with the voltage 1-3 will commence to increase, while the angle of current in line 2 with volts 2-3 will commence to decrease. When the lag is 30 degrees, the current in line 1 is out of phase 60 degrees with voltage 1-3. When the current in line 1 is lagging 60 degrees, it becomes 90 degrees out of phase with 1-3, and thus the wattmeter reads 0. With any further lagging of the current the wattmeter will read negative.

As a matter of fact, in many cases in induction motors at no load this 60 degrees or more lag actually does occur and a negative reading appears in one wattmeter. The reason the other wattmeter does not read negative is that if the current in line 1 gets more and more out of phase with the voltage 1-3, it follows, in any 3-phase circuit, that the current in line 2 gets more and more in phase with voltage 2-3.

The current in an induction motor lags in phase behind the applied e. m. f., due to the magnetising component of the entering current (a true magnetising current, it is well known, always lags just 90 degrees behind the e. m. f. producing it). The apparent input found by multiplying volts and amperes is greater than the real input shown by the wattmeters (in a three-phase motor, the apparent input equals the amperes per line multiplied by the volts between the lines multiplied by the square root of 3).

The ratio between the real and apparent input is the power factor, equal to the cosine of the angle of lag of the entering current. The ratio of the real output to the apparent input is the apparent efficiency, and the ratio of the real output to the

real input is the real efficiency. Thus all these values can be measured as described.

The maximum output can also be found. An induction motor will take increasing load with decreasing speed until a point is reached when it will carry no more and will stop unless the load is reduced. The product of flux entering the armature and the ampere-turns of the armature at this point commence to decrease.

The prony brake method serves well up to about 75 H. P. Above this, owing to various difficulties, it is not always practicable to actually load a motor and measure its output directly. There is a way, however, to measure certain values and calculate the rest. No attempt will be made here to prove the formulæ used, but the method of applying them will be described.*

The three measurements necessary to calculate these values are as follows:—

1. The excitation or running light current, reading at the same time the watts input. This data can best be taken in a curve, such as is shown in Fig. 12.

2. The impedance reading, which is the reading of current input, taken at the same time as the watts input, with the motor standing still. This is shown in Fig. 13.

3. The drop of speed or slip of armature at any definite current input.

From these three readings, together with the resistance of the stator at normal temperature, all the load values of any induction motor can be calculated.

The friction and core losses may be obtained from Fig. 12. The friction is the value of the watts at *F*, allowance being made for I^2R loss during the taking of this curve. The core loss equals the reading at *D*, minus that at *F*.

The I^2R loss of the windings may be read directly from the curves in Fig. 13, at the current desired. The curve gives the sum of the field and armature I^2R, and, subtracting the I^2R of the field, the I^2R of the armature is given.

To obtain the power factor and efficiency at any load, the following equation is used:—

$$\text{H.-P.} = \frac{p\,R_1\,E_0^2\,S\,(1-S)}{746[(R_1+SR_0)^2+S^2(2\pi nL_1+2\pi nL_0)^2]}$$

p = number of circuits (3 for three-phase).
n = cycles in stator.
R_1 = resistance of secondary circuit.
E_0 = voltage applied to one circuit.
S = slip (1 at standstill, 4 at 4 per cent. drop in speed).
R_0 = resistance per circuit of primary.

We now show how to find the various values in the above formula, which, when inserted, permit the calculation of the horse-power. Inserting various values of the slip with the other values which simultaneously go with it, the complete curve of horse-power can be plotted. If the slip is actually measured for a given input, the horse-power output for this input is calculated by the formula above, and thus the complete curve, horse-power, slip, current input, power factor and efficiencies can be calculated and plotted.

If the input of current for a given slip is not measured, it must be calculated as shown in the formulæ later on. We will first assume that the slip is read for a given ampere input, and that the horse-power is to be calculated from the formula above at this slip and input, which thus gives the ratio between output and input for efficiency, and output and apparent input for apparent efficiency and power factor.

If $2\pi nL_1 = X_1$, and $2\pi L_0 = X_0$, then, at the current chosen from Fig. 13, we have

$$\text{current} = \frac{\text{volts}}{\sqrt{(R_0+R_1)^2+(X_0+X_1)^2}}$$

This formula gives us the value of $2\pi\,nL_1 + 2\pi\,nL_0$ for the formula of horse-power above. Since the current and the volts are read and the sum of the resistances can be calculated at any point on Fig. 13, and since the watts read with this curve as taken give the sum of I^2R of both stator and rotor (the core loss being negligible under these conditions), and since I is known, the sum of $R_0 + R_1$ is known for any given stator current; thus $2\pi\,nL_1 + 2\pi\,nL_0$ can be calculated.

The quantities on the right-hand side of this equation are all known except R_1. This is calculated from the three following equations:—

$$E = \frac{E_0\,R_1}{\sqrt{R_1^2+2R_1SR_0}}$$

$I_1^2R_1 = a$ (as obtained from the impedance measurement).

$$I_1 = \frac{SE}{R_1}$$

Here *E* equals the back e. m. f. in the windings, due to motor flux.

These three equations can be used to solve for I_1 or R_1. Thus in the formulæ for horse-power, at any current input for which the slip *S* is measured, all values are known, and thus the amperes input, slip, horse-power output, and hence efficiency, power factor, and apparent efficiency can be obtained.

If, however, the slip is measured at only one current input, and if it is used only to calculate R_1, as shown, the primary current for any horse-power and any other slip can be found from the formula:

$$I_0 = \sqrt{I_{00}^2 + \left(I_{11} + \frac{SE}{R_1}\right)^2}$$

I_0 = primary current.
I_{00} = exciting current.
I_{11} = energy component of exciting current.

At normal voltage exciting current is read and $= I_{00}$. Core loss = K (as found in Fig. 12). Then $\frac{K}{p}$ = core loss per circuit. Hence energy component $= \frac{K}{pE} = I_{11}$.

E = back e. m. f. per circuit produced by the motor flux.
R_1 = secondary resistance.
S = slip.

$$E = \frac{E_0\,R_1}{\sqrt{R_1^2+2R_1SR_0}}$$

Hence the three readings, one running light, with wattmeters and ammeters, one standing still, with wattmeters and ammeters, and one slip reading with simultaneous entering primary current, permit the calculation of all values of any induction motor of any size.

The maximum output equals

$$\frac{p\,E_0^2}{1492\left[(R_1+R_0)+\sqrt{(R_1+R_0)^2+(X^1+X_0)^2}\right]}$$

All these terms have been deduced, as shown, for calculating the horse-power.

The starting torque in pounds at one foot radius equals

$$\frac{S\,E_0^2\,p\,b\,R_1}{17.04n\left[R_1+S\,R_0)^2+S_2(2\pi\,n\,L_1+2\pi\,n\,L_0)^2\right]}$$

n = cycles per second in primary.
b = number of poles in motor.

The remaining terms are the same as before.

TEMPERATURE OF THE VARIOUS PARTS

These should be obtained by actual running, since there is no convenient way of using a no-load method on an induction motor, although full-load temperatures may be deduced from the no-load values, as explained for generators. Particular attention should be given to short-circuited coils. They will not burn out like coils on a direct-current machine, but will take about three times normal current and gradually deteriorate. A hot coil must be located, if it exists, and be replaced. Its high temperature can be felt by the hand.

* For complete proof (without calculus), the reader is referred to the chapter on induction motors, in the author's book on "Alternating-Current Engineering."

AMOUNT OF AIR GAP AND PLAY IN BEARINGS

Since the air gap is so small in an induction motor, being from 0.015 inch in a 10-H. P. motor, to 0.06 inch in a 1500-H. P. motor, it should be uniform throughout. The bearings should not have enough play in any direction to enable the rotor to encroach upon it seriously. The gap should, therefore, be carefully tested with the motor tipped in all four directions. The end-play should be considered, as in an alternator.

SATISFACTORY OPERATION AND STARTING

The starting switch should be tried, if power is available, to see if any sparking occurs as the brushes pass from point to point, and also to see that no jumping of current and undue or too little acceleration occur, as the brushes pass from point to point.

The remaining items, from 13 to 19, inclusive, should be measured and considered as has been described for generators.

In attempting to make the tests here outlined, poor results will be obtained if wrong connections have been made in the windings. Peculiar actions, easily recognized, occur under such conditions. It is assumed, however, that as a part of the test, the fact that the windings are correctly connected shall be determined by noting the balance of electromotive forces and currents.

Iron Reduction by the Electric Furnace

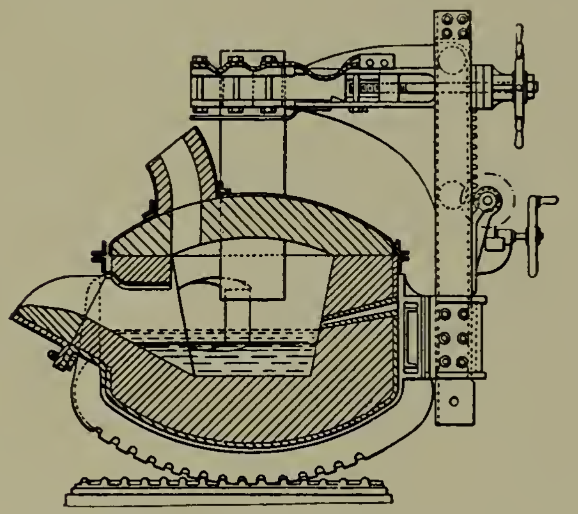
In a lecture recently delivered before the Canadian Club in Toronto by Dr. Eugene Haanel, Dominion superintendent of mines, some interesting matter was given regarding the successful electric furnace trials made by Dr. Paul Héroult, at Sault Ste. Marie.

The vast deposits of iron ore in Canada were hitherto considered of no value on account of the sulphur which they contain, and the scarcity of fuel in the vicinity. Now, it is believed, they may be smelted profitably in the electric furnace, with the practical elimination of the sulphur, the current being developed by the water power with which Ontario and Quebec are well provided.

An experimental plant was erected under the personal direction of Dr. Paul Héroult, and the Canadian Government was represented by Dr. Eugene Haanel. The Lake Superior Power Company provided the building in which the plant was erected, and also the use of a 300-horse-power generating set for four months, free of expense. The Canadian Government gave $15,000 for the tests.

The tests with Canadian ores were conducted almost continuously for about three weeks, and during that time about 150 casts were made, yielding 55 tons of pig iron. In the first tests, hematite, as used by the Algoma Steel Company in their blast furnaces, was emplcyed. For the remainder of the tests different kinds of Canadian magnetite of high sulphur ores, with the single exception of Wilbur magnetite, which is low in sulphur, were employed.

The furnace used in the Héroult process is of the tilting type, shown in the accompanying illustration. It consists of an iron casing lined with bricks of dolomite and magnesite. The hearth is formed of crushed dolomite compressed on top of the dolomite brick lining at the bottom. Two electrodes project through the roof of the furnace. The current passes from one electrode through a narrow air space between it and the



VERTICAL SECTION OF THE HEROULT ELECTRIC STEEL FURNACE

slag line, into and through the slag to the molten metal, along it, through the slag and second air space, to the other electrode.

Alternating current of 4000 amperes at 110 volts was used. The intensity of the current through the bath can be regulated by adjusting the width of the air gap between the electrodes and the slag line. This adjustment may be made by hand, as in the furnace here shown, or it may be done automatically by a specially constructed regulator.

The results of the tests as given in Dr. Haanel's lecture, are as follows: There is no greater difficulty in smelting magnetite in the electric furnace than there is in smelting hematite. It is possible to vary the silicon content as required for the class of pig to be produced. A ferro-nickel pig can be made practically free from sulphur and of excellent quality from roasted nickeliferous pyrrhotite. Ores of high sulphur content can be converted into pig iron containing only a few thousandths of 1 per cent. of sulphur. Titaniferous iron ores containing up to 5 per cent. of titanium can be successfully treated by the electric furnace. Pyrite cinders, resulting from the roasting of pyrite in the manufacture of sulphuric acid, and which at present is a waste product, can be smelted into pig iron in the electric furnace. Instead of coke, charcoal and peat coke may be used as the reducing agent without being briquetted with the ore.

Dr. Haanel suggested that a plant with all the necessary labour-saving devices be designed, having a daily output of from 100 to 150 tons. He said that he understood the Algoma Steel Works paid $3.75 for the hematite ore which they use in their furnace, and that pig iron equal in value and lower in sulphur content could be made by the electric process from high sulphur ores which can be bought for $1.25.

Volcanic Action in the Electric Furnace

In the New York "Evening Sun" of recent date, F. A. J. Fitzgerald draws a parallel between action in a volcano and that in an electric furnace.

"It seems probable," he says, "that the nearest reproduction we have on a very small scale of geological phenomena is found in certain forms of electric furnaces. In one form of electric furnace with which I am tolerably familiar a great mass of material is heated by passing an electric current, generating 1000-H. P., through a conductor embedded in the mass. The result is that the center of the mass is raised to an enormous temperature, estimated at about 7000 degrees F.

"At this temperature all known substances, with the possible exception of carbon, are vapourized. When the electric current is cut off we have a mass of material, the outer part of which is relatively cold, while the center is at an intense incandescence. Since this furnace is built in the form of a large brick box without lid, the only free surface is found on top.

"Under perfectly normal conditions, it is found, by observation, that in cooling, the top of the furnace slowly subsides because of the contraction of the mass in the interior. But it frequently happens that the phenomena attending cooling are different.

"Instead of a slow and uniform subsidence of the whole top of the furnace, a vent-hole forms at some place, and out of this burning gases issue with a loud, roaring sound. Large particles of white-hot material are ejected from the vent-hole with great violence and a miniature crater forms with great rapidity. Presently the rush of gas diminishes and finally dies out.

"Then suddenly a large portion of the surface of the mass at the other end of the furnace is seen to be in movement, sinking in some places and apparently rising in others. This is quickly followed by a renewed activity in the crater, the burning gases again bursting out, and even a new vent-hole and crater forming.

"This is an exact description of the phenomena I witnessed one day when watching an electric furnace cooling down. I have frequently seen similar occurrences.

"It should be noted that while the furnace described above undoubtedly contained molten substances, the incandescent mass, as a whole, was not molten.

"The analogy is obvious. Whether it be more than an analogy is for the geologists and seismologists to determine."

Electricity in a Modern Hospital

THE London Hospital is the largest hospital in Great Britain supported by voluntary contributions. It was recently almost entirely rebuilt on modern lines, at a cost of about $2,000,000, and maintains a thousand beds at an annual outlay of approximately $450,000.

The electric lighting and power installation of the hospital was commenced in 1900, and the work has been going on ever since. The installation is now practically complete, and comprises nearly 6000 lights and about 100 motors. As this is one of the largest and most important installations of its kind in the world, a brief account of its leading features as given in "The Electrical Review," of London, will undoubtedly be of interest here:—

Most of the wiring is in screwed steel tubes. In order to insure that lamps of the correct candle-power shall be used in every room and ward, they are provided with caps of a different shape for each rating, and the holders are made to correspond with them. Thus, no one but the electrical staff of the hospital can alter the candle-power available at any point, and they only by changing the holder. This is a very important and necessary precaution. A number is affixed to each switch, corresponding with a number on the fuse-board with which it is connected, so that in the event of the failure of any light it is an easy matter to identify and examine the fuse controlling the circuit upon which it is run.

The general illumination of the wards is provided by means of three-light clusters suspended in the middle of the rooms, and each cluster is controlled by three switches. The latter are so arranged that one, two, or three of the lamps can be simultaneously alight, or one lamp connected in series with two in parallel, giving a subdued illumination of less than 1 candle-power, which suffices for all ordinary purposes at night without interfering with the comfort of the patients.

In addition to the central clusters, a bracket lamp is hung on the wall near almost every bed, and is connected with a switch plug; the bracket can be unhooked from the wall and stood on a chair, or held over the patient. Each ward is also provided with a portable reflector lamp of 16-candle-power, for use when examining a patient; if the patient is asleep, a resistance in the handle of the fitting can be switched into circuit, so that the lamp gives only about 1 candle power, thus avoiding any risk of waking the patient.

Portable trolleys are provided for administering faradic, galvanic, and X-ray treatment in the wards; these are all controlled by bedside plugs. The ordinary supply for lighting is derived from 240-volt direct-current mains, the circuits being arranged on either side of the three-wire system. This pressure, however, is unsuitable for use in connection with surgical apparatus, and in order to provide not only for this purpose, but also for emergency lighting in case of a failure of the 240-volt supply, a storage battery of 600 ampere-hours' capacity at 12 volts, has been installed in the main building.

The 12-volt supply does away with the numerous portable batteries which would otherwise be required. The current is used for energizing cautery burners, cystoscopes, forehead lamps, electromagnets for removing particles of iron from the eye, for emergency lighting, and for electric bells.

A very neat and compact apparatus hangs near the operating table at a height of a little more than 6 feet from the floor. This fitting contains resistances for the cautery and various lamps supplied from the 12-volt mains, a voltmeter showing the operator what pressure he is using on these lamps, and five wall sockets of different sizes:—one for 240-volt lamps, or a small motor for drilling bone; one for lamps on the 12-volt supply; one for ordinary cauteries; one for specially large cauteries taking about 60 amperes, and one for a ½-H. P. motor used for sawing bone, or for large drills.

The most important department is, of course, that which is devoted to the treatment of lupus by means of the Finsen light. There are two large lamps, each of which treats four patients at a time. There are also four small lamps, two of which are of very recent introduction, each capable of treating one patient. All the lamps in this department are supplied with current at 70 volts.

Various other diseases of the skin are treated in the adjoining rooms with high frequency currents and X-rays. Dr. Sequeira, who is in charge of the Finsen light department, has recently introduced a new apparatus whereby, for the first time, it has been made possible to apply X-rays with a high degree of precision. The switchboard is fitted with instruments for measuring the primary current going to the induction coil, and carries also a motor-driven circuit breaker of the mercury type, to which is attached a regulating dial and automatic cut-off. The dial can be set to any prescribed total number of interruptions, at any desired rate per second, and automatically cuts off the current when the dose is completed. The current in the secondary circuit, that is, through the tube itself, is also measured directly, and the quality of the tube is ascertained by means of a diaphragm provided with a number of discs of metal of various thicknesses, in such a way that at any future date, and with any tube, a given effect can be reproduced to a high degree of accuracy.

Hitherto, although an operator could acquire by experience an approximate knowledge of the results he was likely to obtain under certain conditions, it was impossible for him either to record the conditions with precision, or to communicate his personal experience to others; now, through the application of a scientific method, of which the fundamental characteristic is measurement, to the subject, it has become possible for the physician to write out a prescription for the dose of X-rays required,

with full confidence that his assistants will be able to administer it in quantity and quality precisely as he dictates.

The full meaning of this important advance will be better appreciated if we point out that in the treatment, for example, of ringworm, which is at present being reduced to an exact science at the London Hospital, an error in defect will result in failure to remove the whole of the hair affected with one application of the rays, while an overdose will result in the destruction of the hair follicles, and, therefore, permanent baldness. Now it has become possible by means of a single operation to remove the whole of the hair on the diseased part, with the certainty that it will grow again, and without affecting the adjoining parts. The operator is shielded from the direct action of the X-rays by means of lead glass plates, and in the same way the action of the rays is confined to a region of any desired area. An ordinary X-ray equipment is constantly in use for the treatment of diseases of the skin.

The radiographic or skiagraphic department occupies several rooms, in one of which there is a large frame which is used for the localization of foreign bodies, fractures, diseased portions, etc., in the human subject; an X-ray tube is suspended over the operating table, and another beneath it, radiograms from the two opposite points, by using the upper table, enabling the depth of the shadow-producing substance to be determined. This department is under the charge of Mr. Harnack, whose name is a household word with radiographers.

Other rooms are utilized for the accommodation of apparatus for the application of faradic and galvanic currents, three-phase and single-phase alternating currents, and static electricity. Electric baths for arms and legs, and electric plunge baths are included. The use of faradic and galvanic currents presents no novelty, but the employment of three-phase currents is entirely new and special to the London Hospital. The apparatus consists of a rotary converter and a set of three induction coils, with regulating apparatus.

The use of three-phase currents is a development which will, no doubt, surprise our readers. It certainly shows that the London Hospital does not hesitate to take advantage of every possible means to mitigate the sufferings to which so many of us are liable. The converter is fed direct from the 240-volt mains, but runs very slowly, giving frequencies variable at will from 2 to 5 or 6 cycles per second; the currents are led through the primaries of the three induction coils, the secondaries of which slide over the primaries so as to provide a wide range of regulation. A milli-ammeter is connected in series with one of them. The special uses of the three-phase currents are in the treatment of affections of the internal organs, the application being made by means of three electrodes, forming with the body a kind of delta system, and causing the currents to flow in varying directions through every part of the interior. Valuable results have already been obtained with this apparatus.

Another apparatus consists of a disc with copper segments fixed around its circumference, of which each alternate one is dead, while the intervening segments are connected alternately to the positive and negative poles of the 240-volt mains through suitable resistances. Two brushes bear upon the circumference of the disc, and can be moved relatively to one another. With this apparatus, rectangular waves of alternating polarity are obtained, somewhat after the fashion of the secondary or faradic current derived from an induction coil, but with this fundamental difference, that the frequency, duration, and intermittency of the current, as well as its strength, are all under perfect control. Here again, it will be seen, the principle of exact measurement has been introduced, with remarkable results.

By suitable adjustment, Dr. Morton, who is at the head of this department, has found it possible to contract a muscle entirely without pain,—an important feature, for example, in the treatment of young children, many of whom cannot be treated without the use of anæsthetics, on account of the painful sensations due to the induction coil commonly used. This, of course, is only one of the many advantages gained by the use of the apparatus; the frequency can be varied up to 300 or 400 alternations per second, and every "ingredient," so to speak, can be varied at will, or reproduced with certainty and exactitude, thus making the operator independent of the vagaries of the induction coil with its troublesome contact breaker.

The remaining apparatus in this department consists of a 12-volt cautery, a large Wimshurst machine, and a motor generator giving sinusoidal alternating currents.

Two dowsing heat baths are fixed in the basement. In the aural department a large number of special focus lamps are used, and numerous 12-volt cauteries. The dental department is equipped with five electric motors, four of which are used for driving dental instruments, and one for sharpening instruments. The former are controlled by foot regulators. Tilting suspended lamps and fixed lamps on the operating tables are provided. For the ophthalmic department, a large number of special examining lamps have been supplied; these are arranged so that the light can be thrown in any desired direction, and they are provided with resistances by means of which its intensity can be varied from 1 to 32 candle-power.

The large waiting hall for the out-patients, which provides accommodation for about 800 people, is lighted by means of six arc lamps.

Turning to the heavier applications of electricity, in addition to six hydraulic lifts and a large number which are worked by hand, there are six which are electrically operated. Nearly all the medicines, pills, lozenges, and tablets required for use in the hospital are made on the premises, the dispensary laboratory being provided with fifteen machines for this purpose; these are driven by two motors, one of 10 and one of 15 H. P.

A large refrigerating plant is provided, close to the mortuary; this is driven by a 13-H. P. motor, and, besides circulating cold air through the mortuary, manufactures ice for use in the hospital. In the kitchen there is a large mincing machine, driven by a 4-H. P. motor. A small motor is also provided to drive a machine for grinding and polishing the knives. The laundry is one of the largest private laundries in Great Britain, dealing with about 2,000,000 pieces annually; it is for the most part worked by steam, but the blowers which circulate air through the drying closets, having to work longer than the other machinery, are driven by two $4\frac{1}{2}$-H. P. electric motors. In the room where the surgical instruments are kept, a 2-H. P. motor is installed for grinding and polishing them; and in the sterilizing room, in addition to a steam sterilizer for general work, there is an electric sterilizer for catgut. The remainder of the motors, numbering about eighty-five, are used for driving ventilating fans of various sizes.

A powerful searchlight that throws its rays $7\frac{1}{2}$ miles, so that objects at a distance of $6\frac{1}{2}$ miles can be plainly seen is being tested in Switzerland. The light is placed at an altitude of 3600 feet, and is of 1,000,000 candle-power.

Erection and Maintenance of Electric Lighting Plants

By C. L. WILLIAMS

From a Paper Read at the Recent Convention of the International Association of Municipal Electricians

THE prices on the construction, cost of the items and building steam plants and circuits are not given, but cost of operating arc and incandescent lamps is compiled from reports received from electric lighting plants in the United States. The data given are confined to stations of modest capacities, employing overhead circuits; stations of large capacity with underground circuits are not considered.

A careful analysis of the reports shows that while the cost of fuel and labour varies according to locality and facilities, the cost of production of light and the revenues derived from it adhere to a general average. The reports indicate that the electric lighting station, if properly managed, offers opportunities for large returns on the investment, but, perhaps more than any other business, affords unlimited chances for numerous small leaks, which, taken in the aggregate, will soon equal the revenues derived, unless carefully drawn within the limits of necessary expenditure.

Of the operating stations, 12.6 per cent. are losing money, and with 10.8 per cent. the receipts barely cover running expenses, while 76.6 per cent. are making money, ranging from 2 to 51 per cent. yearly on the investment.

DEPRECIATION

The total average of depreciation amounts yearly to 8.7 per cent. of the entire cost of the plant, exclusive of real estate, showing that the average station is, or should be, rebuilt or renewed throughout every twelve years. Some stations show a profit for the first four years; then a general overhauling of the boilers, engines, dynamos, lamps and particuarly circuits, becomes necessary, due either to inferior and insufficient machinery, incompetent labour, or to the correction of extravagant mistakes in the first construction.

Other stations show a continuous expenditure beyond reasonable operating expenses. When this is applied to the extensions necessary to meet the demands of a growing business, it is entered on the construction account, but when applied to patching the plant to keep lights running it is charged to the maintenance account. The results thus deduced show conclusively that only the use of the very best apparatus and employment of competent labour will yield large returns; also that the employment of a capable consulting engineer, to superintend the erection of the plant, will not only prevent expensive mistakes, but also frequently effect a saving in operation of many times his commission.

In the more recently built stations the percentage of depreciation is considerably less, showing that buyers appreciate the value of good construction, and it would seem that unless the purchaser has sufficient means to build his station properly, he had better abandon his intentions of going into the lighting business.

BUILDING

The building is frequently too small, but never too large. A fireproof building with facilities provided for fire protection and small insurance helps to pay larger dividends than a greater fire risk with double the amount of insurance. The added loss in revenues through the enforced idleness and the decrease in the number of customers makes it imperative to spend enough money on the building to make it absolutely fireproof, rather than rely altogether on insurance for protection against loss.

Ventilation is important. The cooler and cleaner the conditions of the dynamos, the more efficient and serviceable is their operation, therefore large windows are not only desirable, but cost less per square foot than the average wall. In a brick building, a good plan to follow is to build, say, 20-inch brick studs 12 feet apart, putting two window frames 5 feet in width or three 40-inch frames in each panel, except those in which a sliding 6-foot door or double folding doors are located. This construction requires very little of the 13-inch wall and reduces the cost of building and of future enlargements.

A building thus constructed, and with a truss roof in sections to correspond, is easily extended at the two ends. As a steady increase in capacity is the rule in operating, it only becomes necessary to secure a sufficient area of ground which, after building the first section with the unit of machinery decided upon, will permit the extending of the building without wasting money in tearing down and altering the first construction.

Where the size of the building will allow it, a truss roof is preferable to supporting posts. Iron truss roofs are made in portable sections for any length of span, and are reasonable in price, usually costing less than a roof made of wood with iron rods and plates.

When the wood trusses are used they are usually covered with a fireproof coating and the roof laid in slate. Unless a cupola is built in the roof, it is necessary to provide a wood box casing, say 6 feet long and 1 foot wide, in the building wall near the roof, for the easy handling of the wires running from the station. The casing should have a double folding cover so as to permit ready access to the wires, and be painted with an insulating compound. Each wire leaving the station should be covered with flexible tubing, sealed tight with compound having a drip loop and be protected by a lightning arrester thoroughly grounded. Many dynamos have been burned out simply because of poor ground connection in the lightning arrester.

Frequently the arrester is grounded with No. 6 wire twisted around a gas or water pipe, which is entirely inadequate to carry off successive charges of lightning even on a perfect working arrester. Three or four strands of No. 6 or one strand of wire of equal carrying capacity, should be first riveted, then soldered, to a large piece of boiler plate or iron pipe, cleanly scraped where soldered, and buried or driven until embedded in damp or wet ground.

In single-floor stations, not only

the boiler and engine, but each dynamo and all shafting should be placed on a separate foundation laid in the ground, the dynamo base to be thoroughly insulated from the foundation by tar paper and water proofed. No part of the building should be used for the support of any piece of machinery. In good construction the building is only regarded as a cover for the protection of the plant, every part of which is erected as if the building foundation, or walls, did not exist.

Where the building has more than one floor, the girders and supports are of iron; or if built of wood, the slow-burning construction is employed. The best floor is that built on the slow-burning construction principle, namely, 2 by 4 inch or larger timbers as required, set on edge and nailed solidly together, doing away with the wood girder timbers.

Where this floor is built, the dynamos may be fastened to it, but in no case should the floor touch the building wall, but instead should have a separate support. The boiler room should have a cement or concrete floor with a sewer drain running from each boiler, pump and heater. The dynamo foundations should come above the floor line and the floor so laid and drained that it will not only readily dry after scrubbing, but also permit of washing down with a hose.

In ground floors it is preferable to place all piping in the engine and dynamo room below the floor line, and to have the floor of sufficient elevation to allow ample space for easy and immediate access to all piping, valves and connections.

A lifting jack is always necessary. A travelling crane running over each piece of heavy machinery is desirable in case of accident and repairs, but in the smaller stations a fixed support for a chain and tackle will do. Where the fixed support is not readily applicable, an adjusting tripod of sufficient length or height should be provided, and, with its tackle, kept ready for the emergency that always comes. The boiler room is always shut off absolutely from the dynamo room by a fire wall of required thickness, and provided with iron doors.

Upon the completion of a plant, and annually thereafter, a comprehensive test of the efficiency of the boilers, engines, dynamos and circuits will invariably effect a saving of many times the cost of the test, on locating and bringing to light sometimes unexpected wastes which may exist in the per cent. of ashes in the fuel, the amount of incrustation in the boiler tubes, the setting of the boiler, the manner of firing the fuel, method of handling the machinery and quality of supplies.

FUEL

The average cost of fuel is 30 per cent. of the total maintenance account, and is equivalent to a fair quality of free steaming lump coal at $2.70 per ton delivered at the station.

There is no grade of coal that can be taken as a standard, as not only do the different mines vary in the steaming qualities of the coal, but the output from any one mine usually varies in the different veins. The cost of fuel varies from sawmill refuse, costing nothing, to coal at $14 per ton, the price received for current keeping in close proportion to the price of fuel, which is the most variable of the items entering into the maintenance accounts.

The item of the cost of handling coal and ashes is one which, if properly cared for in the construction, increases the percentage of profit. It seems to be economy to build the station where railway facilities permit handling the coal direct from cars to boiler room, even if the distance necessitates an additional first outlay for circuits.

In the larger stations machinery for taking the coal from the cars and delivering it to the boiler grates is in practical and economical operation. The work is done with a small outlay of power and is automatic in its action, feeding and regulating the supply of fuel at a rate proportionate to the pressure of the steam required. Apparatus for this purpose can be installed for $8 per horse-power.

The price of coal used does not seem to greatly change the total monthly fuel account; in stations of about the same capacity, the cheaper the coal, the greater the amount burned. Where the amount used is greater than the average, it is obvious that the boiler-setting and grates are not adapted to the kind of coal used. It appears the higher grades of coal are the most economical, except where apparatus especially designed to suit the conditions is employed to burn the cheaper grades.

WOOD

Wood is burned in 7 per cent. of the stations. Hickory, maple, oak, beech, poplar, elm, chestnut and pine vary greatly in weight, but their steaming powers per pound are about equal, if air dried, and it requires two and one-half pounds of each to equal one pound of average coal. One cord of hickory or hard maple is equivalent to one ton of coal; one cord white oak, 1700 pounds coal; one cord beech, red or black oak, 1500 pounds coal; one cord poplar, chestnut or elm, 1000 pounds coal; one cord pine, 650 pounds coal.

LABOUR

The labour account averages 36 per cent. of the total maintenance account. In the practical operation of a station there should be but one man in authority, who has the entire management as well as the entire responsibility of its successful operation, as there are too many details of too varied a character to divide either the authority or the responsibility.

If an employee, in no matter what capacity, proves by results, or lack of results, to be incompetent, no question of sentiment nor expediency should prevent his immediate discharge, because a careless or unskilled man is in a position to injure and disable thousands of dollars worth of machinery.

The average price paid to the various employees in and about a station is as follows:—

Managing superintendent, per month, $152.70.

Electricians in charge apparatus, per month, $84.70.

Engineers, per month $82.40.

Firemen, per month, $49.10.

Wiremen, per month, $58.18.

Linemen, $50.28.

The figures represent the average of wages paid as shown in the station reports, and while giving the basis of an estimate should not govern the scale paid in any particular station, which naturally depends on local conditions such as size of station, extended duties, cost of living and individual worth.

The labour accounts vary less than the fuel accounts in the stations of different capacities. The plant that is sufficiently large to economize in the station labour requires additional help in the office force and to a considerable extent in the line construction account. Reports showing a small labour account invariably have a correspondingly large fuel, repair or rebate account, and they clearly demonstrate that well paid labour increases the profits of lighting plants.

Capable expert services are of great value in the prevention of costly mistakes in construction, but the title expert is usually a misnomer, and the employer too frequently gets "whip-sawed" in the exchange of expert services for cash. As has been often shown, the "expert" experiments with untried theories, or rides an expensive hobby with the net result of diminishing the station economy in direct ratio to the employer's bank account.

The experienced expert, who is a mechanical as well as an electrical engineer, is better equipped to design and construct a station than a college graduate whose only qualifications are a diploma and a distant relationship to some stockholder.

BOILERS

No one type of boiler is better than every other type for every set of conditions. Each type has its favourable conditions for efficient production of steam. A high economy in the use of steam is most readily reached by good judgment in the selection, setting and firing of boilers that are adapted to the fuel used and to the existing conditions of the service required.

For the smaller plants any well made, properly set, horizontal tubular boiler will be found satisfactory. In the larger plants the water-tube type is generally preferable on account of its greater steaming capacity, less floor space and somewhat higher efficiency.

In the economy of any type of boiler, the fireman is the most important factor. He is the man that shovels the dollars under the boiler, and a man will save many times the amount of apparently higher wages. A defective setting greatly increases the waste of fuel which, where properly reset, effects a saving often reaching 50 per cent. of the amount of fuel formerly used.

Where two boilers are set together, add 6 inches additional to center wall; common brick is estimated above the floor line. Add enough to complete the floor line which may extend over the entire boiler room unless cement is used.

Down-draft and other patented forms of furnaces are usually applied to water-tube boilers, although they may be and are applied to any type. Properly built, their use diminishes the fuel consumption, prevents smoke, increases the capacity of the boiler, and by greater powers of combustion permits the use of the low grades of coal. The various makers of furnaces claim that their apparatus will do away with 90 per cent. of the smoke, burning any grade of coal, increase the efficiency from 20 to 50 per cent. over common setting, and show an economy of from 15 to 30 per cent. in saving coal bills.

These claims are fulfilled in practice with a margin of allowance. Their success depends on the ability of the fireman, size and height of chimney, and the amount of work required of them as compared to the capacity of the boiler. A good fireman with a fair set of boilers will rarely have a smoky chimney, but where the conditions are cramped or unfavourable and it becomes necessary to abate the smoke nuisance, a suitable furnace, apart from any added economy, becomes imperative. The average price is $3.50 per horse-power.

ENGINES

The best engine is none too good. All of the standard types of engines are efficient when properly proportioned, and the other factor that determines the quality of the engine purchased is the shop facilities of the makers. Thoroughly equipped works can put together a good engine, while a shop without the tools is bound to turn out a poor piece of machinery, no matter how good the design.

When investigating engines the buyer is often at a loss to decide between the Corliss and high speed. In a general way he gets an impression that the Corliss is the best; but by the time he buys engine, shafting, pulleys and belting, the cost is double that of high speed, flexibility and durability. Regarding economy, he will usually figure on a single-cylinder engine and estimate three pounds of coal per horse-power for the Corliss, and four pounds of coal per horse-power for the high speed (which economy he rarely gets) but he finds that unless the unit of generators is going to be sufficiently large to belt direct or directly connect to the Corliss shaft, the power required to turn the engine and fly-wheel and drive the necessary shafting, pulleys, idlers and belting sometimes eliminates the difference in steam economy.

He also finds the economy dependent on the steam pressure and the load carried, and in a general way figures that if the average load will exceed 50 per cent. of the rated capacity of the engine, the Corliss is preferable, but if the load is less than 50 per cent. of the engine capacity, particularly if it is variable, the high-speed engine is more economical and more easily handled. He may also come to the opinion that the greater durability of the Corliss is offset by the wear and tear on shafting, bearings, clutches, pulleys, belting or rope, or he may conclude the reliarope.

The Corliss engine consumes 8 per cent. of the steam delivered by the boilers in turning itself and fly-wheel over. The shafting and belting consume 12 per cent. of the horse-power of the engine, thus the horse-power delivered to the dynamos is 84 per cent. of the horse-power delivered by the boilers under ordinary conditions. The frictional load of high-speed engines averages 5 per cent.

The average coal consumption is one pound coal for every seven pounds of water evaporated. The average Corliss efficiency is twenty-six pounds water per delivered horse-power per hour, the average high speed being thirty-two pounds water per delivered horse-power per hour.

Since different engines require different amounts of steam to produce a horse-power, the standard by which the horse-power of an engine is gauged is the amount of water required per horse-power per hour. This, according to Professor Thurston, in good engines is equal to the constant 200 divided by the square foot of the steam pressure. In the best engines this constant is as low as 150. This gives for high-grade engines, working, say, at eighty pounds steam pressure, 22.25 pounds water, and in the most economical engines, working at 100 pounds steam pressure, fifteen pounds water per horse-power per hour. However, it is shown in tests made in operating stations that in regular practice at eighty pounds steam pressure a fair average shown is as follows:—

Single-cylinder, non-condensing, high-speed engines, thirty to thirty-six pounds water per horse-power per hour.

Corliss engines, twenty-six pounds water per horse-power per hour.

Compound condensing high speed, twenty-one pounds water per horse-power per hour.

Compound condensing Corliss, sixteen pounds water per horse-power per hour.

Reducing this to coal (one pound coal evaporating seven pounds water). Single non-condensing high speed, four to five pounds coal per horse-power per hour.

Corliss, three and one-half pounds coal per horse-power per hour.

Compound condensing high speed, three pounds coal per horse-power per hour.

Compound condensing Corliss, two and one-quarter pounds coal per horse-power per hour.

Compound engines have a supposed economy over single cylinder of 12 per cent., but experience with compound engines would indicate that this economy is not obtained except where a nearly constant full load and high steam pressure are carried, or the engine is used condensing. Triple expansion engines do not come within the limit of this paper except in direct-connected work running from 150 H. P. up, the makers of which engines promise the highest efficiency.

The Distribution of Electricity in Mines

THE use of electricity in mines is now becoming very general, and in connection with the practice, the types of cable that should be used in the various situations and the most satisfactory methods of installing them are very important matters. These are discussed in an article in "The Electrical Engineer," of London.

It is there claimed that the kind of cable that will suit one colliery will not be acceptable in another, and what is right for, say, the pitshaft is not always to be recommended for the underground roads of a mine. This diversity of practice is accentuated by the differing systems of electrical distribution, such as continuous current and alternating three-phase current, which also embody the various tensions in use,—commonly, from 100 to 3000 volts. And, as different systems of mains are used in each mine for the different purposes—such as lighting, power, and signalling—so considerable variety of materials and methods may be required for use in connection with one and the same colliery distribution scheme.

The type of cable used, in the early colliery installations, for all classes of work was vulcanized india rubber; and to this day it is the best, particularly the rubber installation as then manufactured. But there are cheaper made cables now on the market, and, as the question of prime cost is an important one with many, such less expensive cables are more generally used for present-day work. These more modern cables are divided into two main classes:—bitumen sheathed and lead sheathed, which classes are further divided as to insulation and protecting materials, as will be shown.

The plain bitumen cable mentioned is the class that has been very generally used for town lighting and tramways. In the best makes it consists of a solid sheath of specially prepared bitumen applied under pressure to the copper conductor, and then lapped with strong tapes, being further protected with jute or other lapping as required. The suitability of this for use as a single-conductor cable is undoubted where there is no chance of undue heat being applied, either externally or through overloading the conductor. In cases where such overheating might tend to decentralize the conductor, or where multiple-conductor cables are required (if neither rubber-covered or metallic-sheathed mains are allowable), the conductor is first covered with a layer of impregnated paper or fibre, and then sheathed with bitumen either completely around the paper on the single-conductor type of cable or over the outside circumference on the multiple-conductor type, the conductors themselves being insulated from one another by the paper covering. It will be seen that the paper makes a more solidly mechanical dividing medium between the copper strands working at different potentials than can be hoped for with such a plastic substance as bitumen. If, however, the bitumen is unduly stiffened in manufacture it tends to become brittle, so that bending in cold weather may cause it to crack.

The use of the paper separator is further valued in colliery work by its ability to withstand the increased liability to overloading that is involved when, for instance, coal cutters get jammed or when trucks run off the rails, thus increasing the current passing. The liability of these all-bitumen cables to decentralize is increased by the fact that such cables are usually hung upon cleats or other suspensions at intervals, and are liable to have their weight at such points of suspension increased by their use as occasional cloths lines and tool racks. Some insistence is made upon this point—namely, of the necessity for a mechanically strong insulating separator in such a type of cable, as the fact does not seem to be as well known as it should in mining circles.

The lead-sheathed type of cable is also served with paper immediately under the lead, as in the standard town-lighting type, but this also requires further modifying to suit the special circumstances of colliery work. In this instance it is the lead that is liable to be affected, either by the peculiarly deleterious pit water or by the exceptional conditions of wear and tear associated with colliery working. As a rule, therefore, lead-sheathed cables are used more as a base to work upon as regards protection, than as the completed article, in this class of electrical distribution. Rubber-covered cables are still used for the lighting and motor connections, but their general use as a main cable is, as before mentioned, out of date.

It will be seen, therefore, that the following styles of cables are in use:—

Vulcanized rubber insulated, braided over all.

Bitumen insulated, braided over all, or jute served, and possibly further protected by armouring.

Paper or fibre insulated, bitumen sheathed, and protected as above.

Paper insulated, lead covered, and protected as above.

To take a concrete instance. A coal mine is to be worked by electricity,—the lighting, the coal-cutting, the screening and washing machinery, the ventilating, the hoists, mechanics' shop and, in fact, everything but the main winding gear is to be worked from the dynamo-house. This mine instanced is one providing household coal, which means that it is less likely to be dangerous, as regards firedamp, than a steam-coal mine. Its workings are fairly compact, so that there would be little power loss in the mains. It is, therefore, decided to use continuous current. The voltage is 500, the feeder cable down the shaft is to be 0.5 square inch, and the distributors in the workings vary from 0.25 to 0.05 square inch. The question arises as to the best type of cable for these requirements.

Taking the surface work first, the cables for the screens, the washery, the mechanics' shop, and the pithead lighting are usually cleated overhead, and are subject to rough usage, heavy vibration, and extreme weather conditions on their way from the dynamo-house to their current-consuming devices. The best possible class of cable should, therefore, be put in here, such as the rubber-insulated type, heavily braided and compounded, with a coat or two of varnish painted over when cleated in position. The cleats should be of wood, and should have the square bearing edges slightly chamfered off. They should not grip the cable too tightly. A piece of brattice cloth, or of hose pipe, placed around the cable at the point of support, will lessen the effects of vibratory friction common to such situations. If the dynamo-house is some distance away, such as would be the case where power is generated at one center for several pits, the feeders would required to be laid either underground or erected on poles. If public property has to be traversed, the underground system should be used, with either paper-insulated, lead-covered or bitumen-isolated, jute-served cables. The method of laying these depends upon the possibility of further extensions later. If no extensions are likely, a solid pitched-in system is recommended, composed of stout creosoted wood or asphalt trough, the cables resting on asphalt bridges and filled in all around with tempered pitch or bitumen to a thickness of about ½ inch, finally being covered

by hard tiles or asphalt concrete to avoid mechanical damage.

If, however, a probability exists of further or heavier cables being required, iron or stoneware pipes should be laid for drawing the cable in. The cables should be further protected by jute serving to prevent abrasion when being drawn into the pipes. Draw boxes should be built at maximum intervals of about 100 yards, on straight runs, for this purpose. The joints should be made by the cablemaker's own men, as they are more expert at this special class of work than ordinary electricians can hope to be. Further, supervision should be given to the whole of the work by a representative of the cablemaker, who in such a case would guarantee the work for a period of time (usually a year) from faults due to manufacture or laying. Incidentially it may be mentioned that there has been a growing tendency among users of cable to be satisfied with the supervision of their own officials, or at the best of a jointer or foreman from the cablemakers, and this comparatively unskilled or irresponsible superintendence has often led to much trouble upon the cable portion of the work at least.

If the whole of the route from the power-house to the pithead is private property, and it is any appreciable length, the conductors may very well be erected overhead on insulators fixed to poles. The poles should be of the stout telegraph type, the cross-arms of well-seasoned oak, and the insulators double-shed porcelain, with ample room underneath for cleaning between the sheds. The conductors need not be stranded with small wires, but may be built up of either No. 0, or 00, or 000, or 0000, whichever is the most convenient multiple of the sectional area of conductor required. Thus, for the 0.5 square inch conductor mentioned, four No. 0000 of 0.125 square inch each would make the exact size. If these are each erected and strained up separately, then lashed to the insulator with soft copper wire, a solid and simple arrangement will result. It should be noted that if the whole of the conductor is erected in one section, it is harder to get such a flat curve as by straining it up in detail.

The cable for the pitshaft is next to be decided on. There are many types of cables and different methods of fixing in general use, and each arrangement is considered by its erector as the best. As a rule, such arrangements are the best for their own particular job only. To summarize some of these in order of simplicity:—The lightly insulated cable with a single insulated suspension at pithead is specially fitted for the local circumstances of a wide pitshaft where ample spacing can be allowed. In narrower shafts, the tendency would be for the conductor to swing into mutual contact, with disastrous effect where dampness occurred. The cables there are mostly triple braided, so that in a dry situation but little leakage or chance of damage to a person touching them should result. The chief advantage is that there are no intermediate supports upon which deteriorating influences may make a base for attacking the insulation of the cable; and, further, the cable is cheaply insulated.

The next system, in point of simplicity, consists of insulated and armoured cables, also suspended from the pithead only. This suspension is made from the galvanized iron wire armouring, of which there are two layers, to a steel hanger to which the armour is attached, and which has eyes to hold the chain slings or other suspensory arrangements. The armouring, therefore, acts as a protection from damage, and also takes the strain off the pendulous cable.

The next most usual practice is to clip the cables up to the buntons by means of cleats, spaced at intervals of from 10 to 100 yards, depending upon the size of the cable or the distance between the buntons already installed for supporting other items of mining transmission. The length of cleat would depend upon the length of span, but it varies from 2 feet in length in general practice. The cleats, however, cannot be made too long, and will be the safer for a packing between the cable and cleat, such as split rubber hose pipe. The methods of fixing the cleats are various and suited to the arrangement of the bunton, to which it is either clipped, or bolted to, or supported upon with intermediate girders. A stout roofing hood should be screwed on the top of the cleat, to deflect falling material; and special attention should be paid to the protection of the cable at this point.

In some instances, cables are run down an iron barrel, which is screwed together in 9-foot lengths and supported at fairly long intervals up to 50 yards. The cable is then held in a long cleat at the top, which cleat is fastened to the pithead timbering, cable cleats being further used at the pipe-supporting buntons. These pipes and their erection are somewhat expensive, but they make a first-class job, especially with a rubber cable.

Efficiency of the Luminous Arc Lamp

In a recent paper read before the Illuminating Engineering Society, of New York, E. L. Elliott said that in the matter of efficiency as a light producer, the luminous arc is revolutionary. Measurements made by the Electrical Testing Laboratories with lamps producing the yellow light gave the following results, as compared with an enclosed arc:—

	Luminous Arc	Enclosed Arc
Mean amperes	8.	5.1
Mean volts at arc	45.	81.
Mean watts at arc	360.	413.
Mean spherical candle-power	1020.	232.
Mean lower spherical candle-power	1560.	260.
Watts per mean spherical candle-power	0.353	1.78
Watts per mean horizontal candle-power	0.265	1.59

In actual light production the luminous arc is, therefore, practically five times as efficient as the enclosed arc. The lamps tested were run on direct current, and were fitted with opaline globes of practically equal density.

While the price of the carbons themselves is higher than the price of the best pure carbons, the cost per candle-power-hour figures out exactly the same. The smaller lamps run ten hours with one setting of carbons and the larger lamps fifteen hours.

Besides the increased efficiency of the lamp, other advantages are the superior colour and steadiness of the light and the better distribution.

On account of its greater length the arc is naturally very sensitive to air currents, and it is, therefore, necessary to protect it from draughts. Since there is also some vapour generated, which must be allowed to escape, provision must be made for a restricted access of air and the discharge of the vapours. This is accomplished by providing a small inlet at the bottom of the globe and a corresponding protected outlet at the top.

The most serious objection that can be urged against the lamp at present is the greater amount of attention required. It is in this line that efforts are at present mainly directed toward improvement, particularly toward combining the long life of the enclosed arc with the efficiency of the luminous arc.

The Massachusetts Railroad Commissioners have given the Old Colony Street Railway system of the Massachusetts Electric Companies authority to carry freight and express matter over its lines between Boston and Fall River.

Electrical and Mechanical Progress

Electric Train Lighting

ELECTRICALLY lighted trains are one of the advertised luxuries of modern American railway travel, and the comfort and convenience of an individual electric lighting service, as well as an easily controlled general illumination, have led to the development of many schemes to furnish the necessary current. In practically all these devices, the storage battery is used as an auxiliary, combined with axle-driven generator units on each car, or a single steam-driven generator on the baggage car or engine. One of the simplest and most reliable forms of these methods of lighting is the "floating battery" system, including one of the Curtis steam-turbine-driven generators made by the General Electric Company, of Schenectady, N. Y.

On electrically lighted Pullman or passenger coaches, the usual lamp equipment requires a maximum electrical output of from two to three kilowatts per car. A generator capacity of 20 kilowatts usually suffices, but the turbine sets just mentioned can be obtained in the larger sizes to comply with more severe load conditions.

The Curtis steam-turbine generator set for train lighting work consists of a non-condensing single-stage steam turbine, direct connected to a 20-kilowatt, two-pole, compound-wound generator. The speed—of 4500 revolutions per minute—is low enough to eliminate all bearing trouble and vibration, and at the same time high enough to permit a very compact and efficient generator design. The

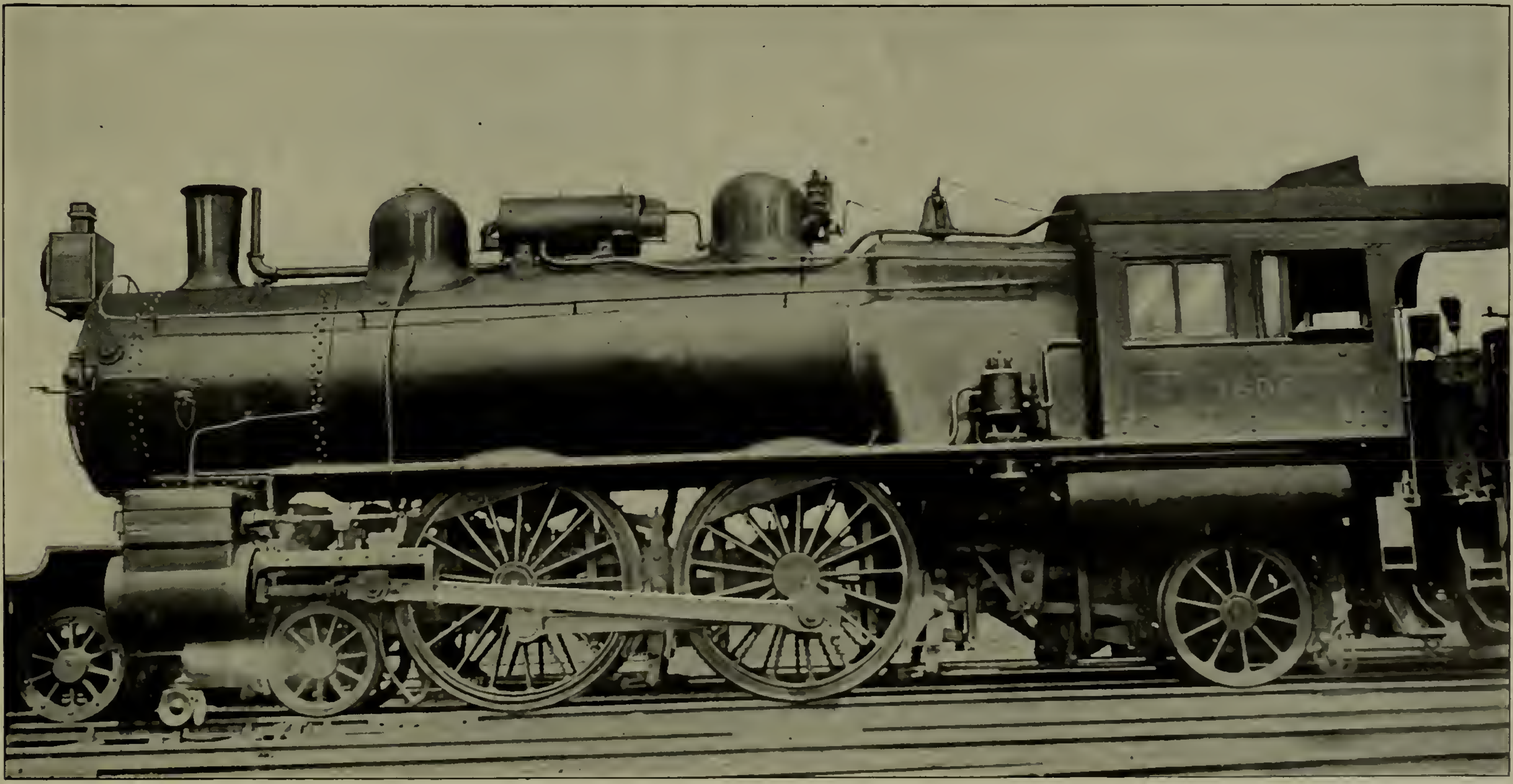


FIG. I.—LOCOMOTIVE EQUIPPED WITH A CURTIS STEAM-TURBINE-DRIVEN GENERATOR MADE BY THE GENERAL ELECTRIC COMPANY, OF SCHENECTADY, N. Y., FOR ELECTRIC TRAIN LIGHTING

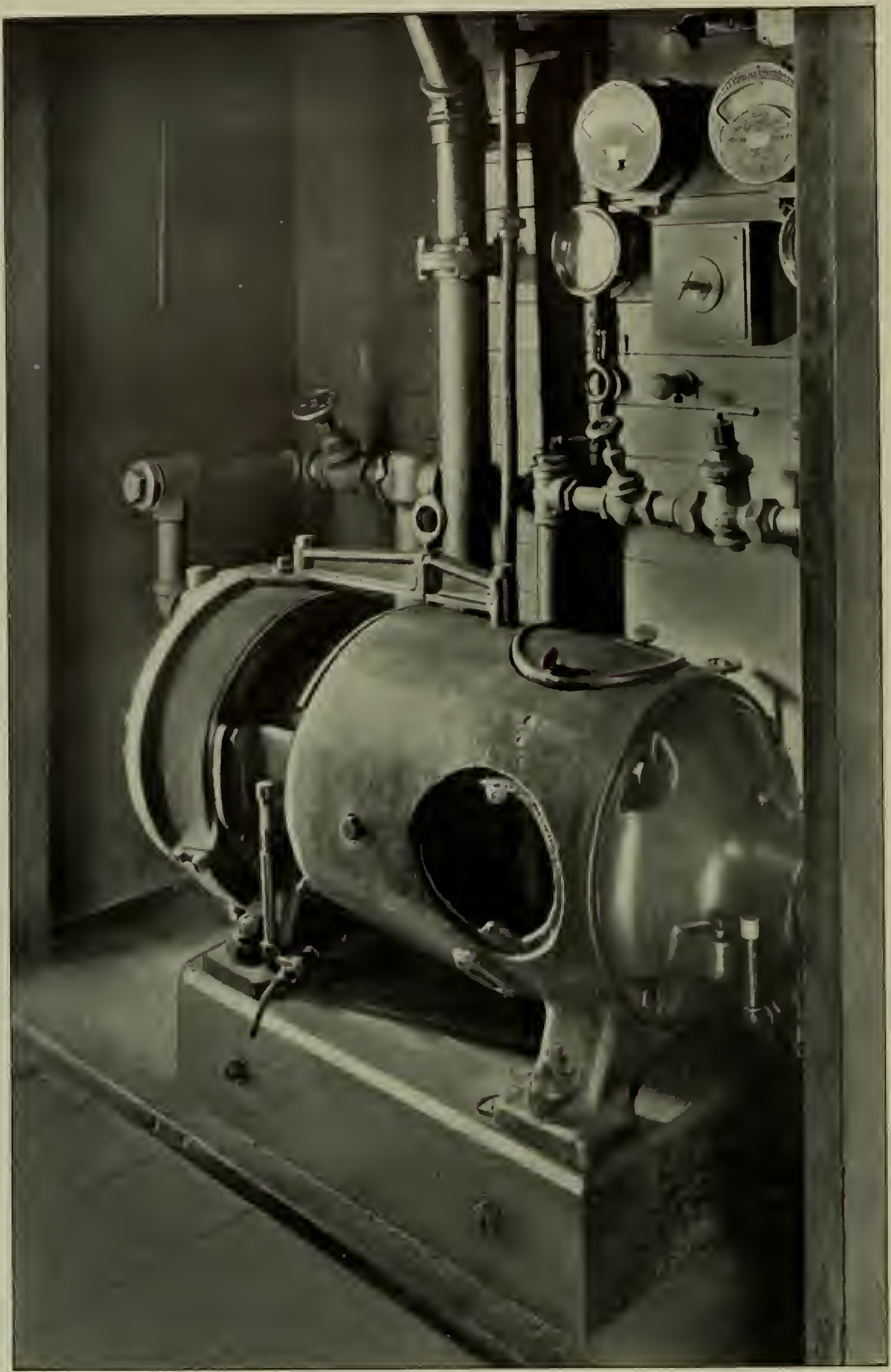


FIG. 2.—BAGGAGE CAR EQUIPPED WITH A CURTIS STEAM-TURBINE-DRIVEN GENERATOR FOR ELECTRIC TRAIN LIGHTING

generator is completely enclosed, but is provided with easily removable covers, so that all parts of the machine are readily accessible.

The exhaust outlet is so designed that it may be either right or left handed, and when the turbine set is mounted on the locomotive boiler a special exhaust fitting can be attached so that the turbine can exhaust into the locomotive stack. The complete turbine set is 64 inches long, 23 inches wide, and 24½ inches high, without eyebolt and lifting bar. It weighs 1850 pounds.

Because of its compactness and comparatively light weight, this turbine set may be mounted either in the baggage car or on the locomotive. When operating conditions will permit, the best place for the turbine is on the locomotive, as shown in Fig. 1, for here full boiler pressure may be used and no high-pressure steam couplings are required between locomotive and baggage car. When located in the baggage car, however, as shown in Fig. 2, the turbine set occupies little space, and there is no vibration. Moreover, so little attendance is required that the outfit need be overlooked only by the regular baggage-man.

The second unit in train lighting practice is the storage battery. For trains running solid between termini, the battery should consist preferably of a single group of cells of small capacity located in the baggage car.

On suburban trains where the locomotive is not changed from one end of the run to the other, the battery may be entirely dispensed with. Where trains are not run solid between termini, cars transferred to other lines have to be provided with independent batteries if electric lighting is to be maintained on them when running on the branch lines. In this case, the capacity of the battery must be somewhat increased, depending upon the length of the run and the operating conditions.

Normally, the battery consists of 56 cells, whether used as a unit or distributed through the cars. These cells are often assembled in a lead-lined tank, the battery elements being supported by an insulating cross-piece, and insulated from the sides of the lead lining by rubber sheets. In order to facilitate handling, the wooden crates usually contain two or more cells, according to their size, these being in turn installed in two battery boxes underneath the car, one box, containing half the battery, being located on each side of the car. The battery boxes are made of wood, and these as well as the crates or tanks are thoroughly coated with acid resisting and insulating paint, so that there is very little danger of grounding the batteries. As a further precaution, however, it is customary to mount the crates upon porcelain insulators.

A simple switching equipment is used to connect the batteries and turbo-generator. This is located either in the baggage car, the locomotive cab, or in both, depending upon the operating conditions and the location of the turbine. The switching equipment, as shown in Fig. 3, comprises a voltmeter of special construction, to withstand the vibrations of the train; a transfer switch, to connect the voltmeter either to the generator or battery terminals; a field rheostat, for the generator; a double-pole single-throw switch with enclosed fuses, for disconnecting the storage battery from the train line; a double-pole automatic circuit breaker with reverse-current relay and double-pole field switch, for disconnecting the generator from the train line in case of a shut-down of the turbine. The double-pole, single-throw switch is required only when a single battery is used. When individual batteries are installed on each car, separate

switches for each battery are required, and these are considered as a part of the lighting equipment of the car.

The field of the generator is normally connected to the train line out-

broken up, without first disconnecting the couplers by hand. Each coupler has sufficient capacity to carry the entire load, so that only the couplers on one side of the platform need be connected.

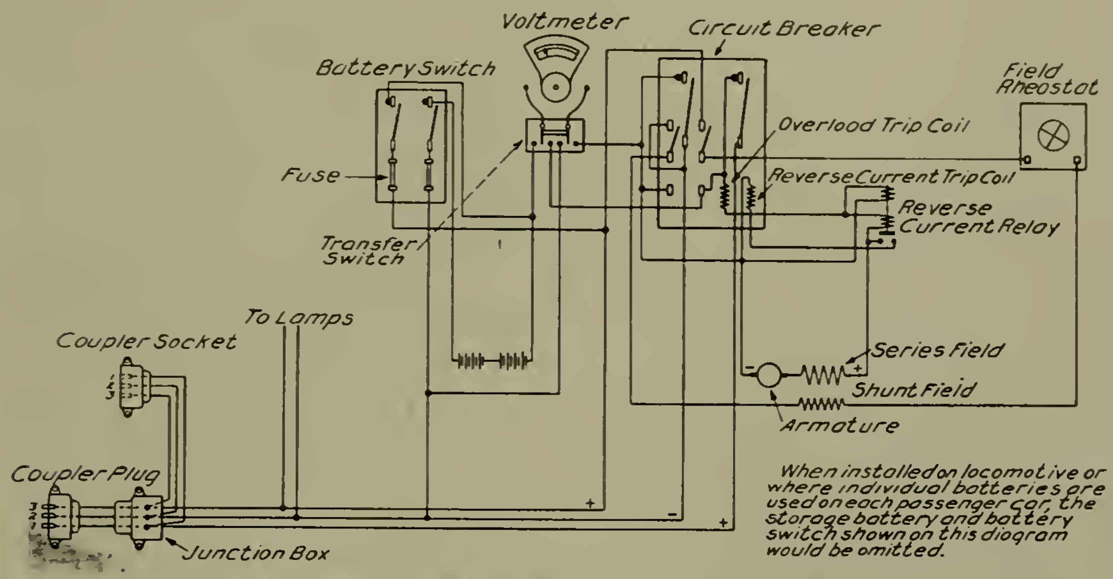


FIG. 3.—DIAGRAM OF CONNECTIONS BETWEEN THE BATTERIES AND TURBO-GENERATOR

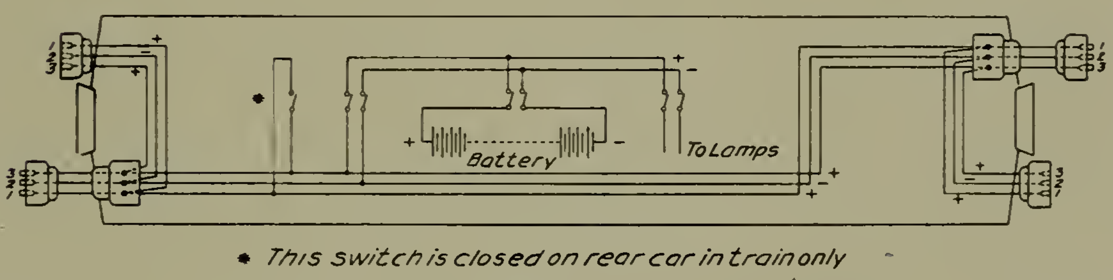


FIG. 4.—DIAGRAM OF CONNECTIONS IN A PASSENGER CAR

side of the automatic circuit breaker, so that the field will be excited in the proper direction from the battery. This prevents the possibility of the generator being thrown in reversed. When the circuit breaker is open, the field is automatically connected directly across the generator armature, so that the lamps in the locomotive and baggage car can be lighted. The field is automatically connected to the train line by closing the circuit breaker prior to the closing of the main contacts.

The passenger cars equipped with this train lighting system are interconnected, as in Fig. 4, by a three-wire train line cable. The size of the conductor used depends entirely upon the length of train and the lighting load per car. For a train of seven coaches, each with a maximum load of $2\frac{1}{2}$ kilowatts, each conductor would be No. 00 B. & S. cable. The train cables terminate at each end of the car in a junction box, to which the leads to the couplers are also connected.

Each coupler plug is hung by a chain from above, to prevent its striking the ground when pulled out of the socket. All parts of these couplers are strong enough to withstand jerking apart if the train is

In operation, the battery is normally connected directly across the train line, and is usually proportioned to give approximately 110 volts at its normal discharge rate. The capacity of the battery will vary with the service conditions, but ordinarily it should be of such size that the one-hour discharge rate will be equal to the full load required by the entire train. Practically, the only function of the battery is to insure the continuity of light when the locomotive is temporarily disconnected from the train. Under normal conditions, the battery "floats" on the line, neither charging nor discharging, the slight depletion of the battery charge being made up during periods of no load, by increasing the generator voltage.

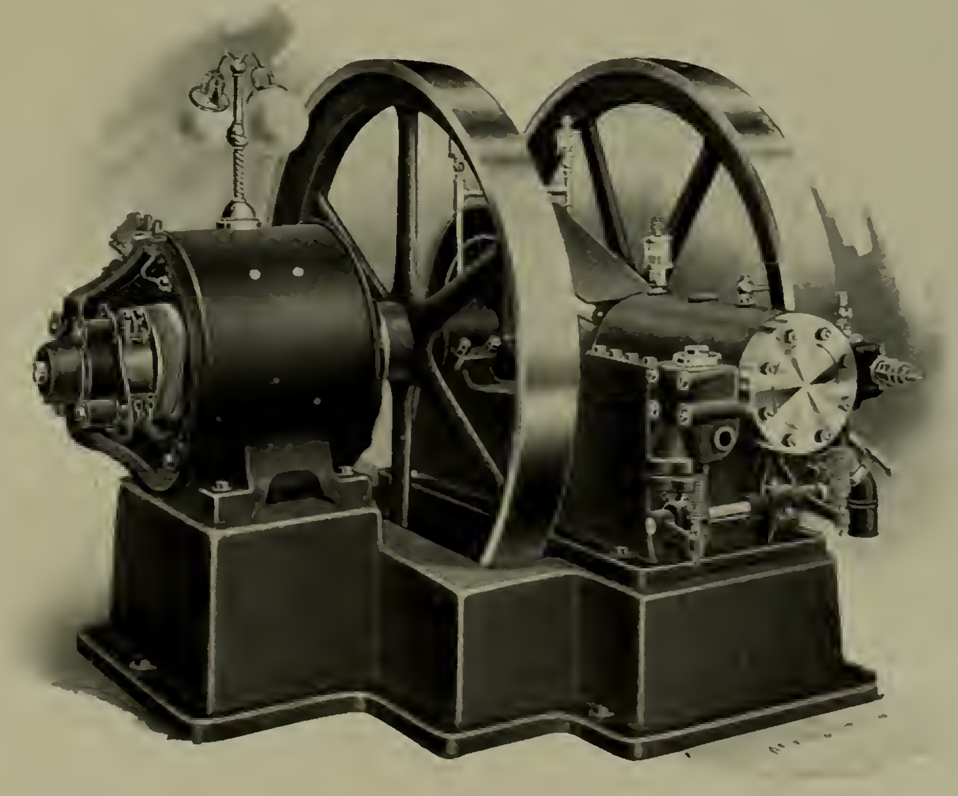
A Gasoline Engine for Driving Electric Generators

ONE of the principal uses of the gasoline engines built by the Foos Gas Engine Company, of Springfield, Ohio, is for driving electric generators, as shown in the accompanying illustration.

Among the features of this engine which have been given special attention is the wipe spark electric igniter. This part is simple in construction, positive in action, and is claimed to permit no loss of fuel or power from missing explosions. It is self-cleaning, and the contact points, on account of their rubbing action, are kept polished and free from dirt and carbon.

The governor also is very simple in construction; it is very compact, and is so placed as to be easily accessible, but still well-protected. It automatically takes up its own wear, and is adjustable for speed without stopping the engine.

As the governor acts only on the fuel valve, the motion of the inlet



A GASOLINE ENGINE BUILT BY THE FOOS GAS ENGINE COMPANY, OF SPRINGFIELD, OHIO, FOR DRIVING ELECTRIC GENERATORS

and exhaust valves is uniform, whether or not the engine takes its charge of fuel. With this system a current of cold air passes through the cylinder on the idle strokes, freeing it wholly from burned gases and cooling the valves and igniter. If desired, these engines can be equipped with a throttling governor, so that the variation of speed from full load to no load ordinarily comes within 2 per cent.

As an evidence of the careful construction, it is claimed that the counterbalancing is so refined as to permit operation of the engine on rollers, leaving the engine free to move in any direction. The method of counterbalancing is by means of discs attached to the arms of the crankshaft. Many of the Foos engines have been operated on rollers at various expositions and fairs in different parts of the country, and this distinctive feature has attracted great attention wherever shown.

The type of engine here illustrated is built for direct coupling and for belt connection, and is adapted for use in store, residence, and factory lighting. These engines are equipped with heavy fly-wheels having wide crown faces to carry the dynamo belt. They have been on the market for more than nineteen years, and each one is thoroughly tested before leaving the factory.

A MOTOR-DRIVEN CARPET SWEEPER MANUFACTURED BY THE HUTCHISON ELECTRIC CARPET SWEEPER COMPANY, PITTSBURG, PA.

Gas Engines for Railway Service

THE Westinghouse Machine Company, of East Pittsburg, Pa., has recently contracted with the Olean Street Railway Company to install in their power house at Ceres, N. Y., two gas engines for supplying current to the railway serving Olean, Ceres, Boliva, and other towns. In the near future power will also be supplied to an interurban railway system between Olean and Salamanca, N. Y., a distance of 15 miles.

The engines are to be of the Westinghouse horizontal, heavy-duty, double-acting type, with single cranks, and cylinders of 22-inch diameter by 30-inch stroke. Each unit will have a normal capacity of 500-B. H. P., running at 150 revolutions per minute. They will operate on natural gas having a calorific value of approximately 1000 B. T. U., this being very plentiful in that territory.

The engines are to drive 300-KW., 25-cycle, alternating-current generators, operating in parallel and supplying current at 380 volts to a high-tension, three-phase transmission-distribution system through step-up transformers. At present the Olean Street Railway Company has a steam power plant in service, burning gas under boilers, and a large saving is contemplated in using gas power.

Recent Motor Applications

A RECENT electric motor application, which will go far toward detracting from the terror of "sweeping days" in private residences and the cleaning of carpets in a hotel, is the electric carpet beater and sweeper illustrated on this page.

This machine is made by the Hutchison Electric Carpet Sweeper Company, of Pittsburg, Pa., and not only sweeps the carpet, but also beats it, to loosen the dirt to be swept up. It is readily connected with any electric light socket by means of lamp cord.

The beaters are metal balls attached to the brush by means of a link and helical spring. They strike the carpet 2000 times a minute, causing the dirt to loosen so that the brush may sweep it into the receptacle. The machine is so constructed that as the brush wears down it can be lowered in a minute's time.

The only labour required on the part of the operator is to guide the machine. The expense of running the sweeper is said to be very small. Motors are provided for either direct or alternating current. The

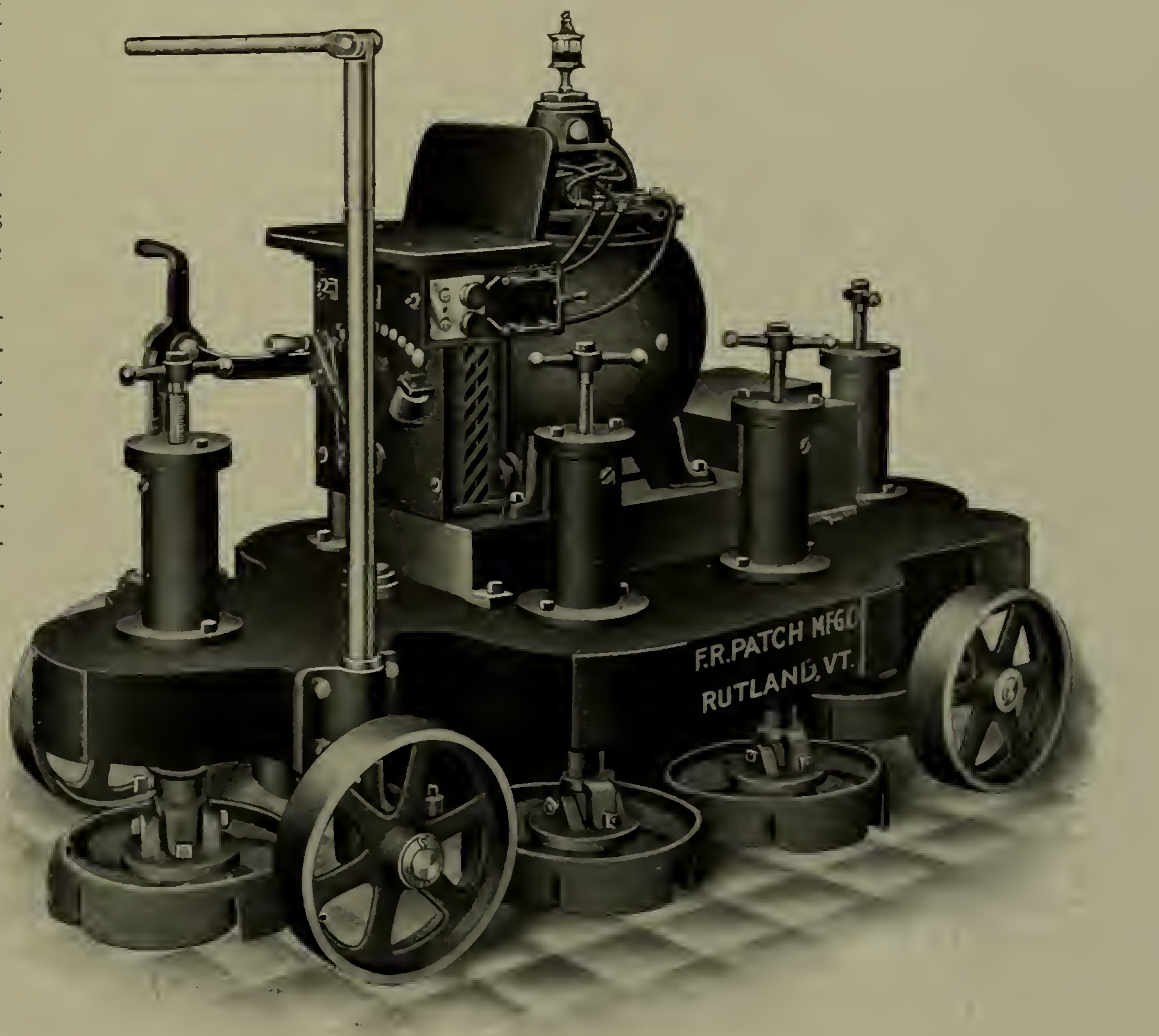
cost of the complete machine is $100, and brushes may be renewed for $3.50.

Another interesting application of the electric motor is for the driving of stone mosaic floor finishing machines. Before these came into use the smoothing and polishing of a stone or mosaic floor was a slow and laborious task, done by hand. Now, however, the only hand work is in guiding the machine from one point to another.

The motor used is a $7\frac{1}{2}$ horse-power vertical type machine, allowing the simplest possible arrangement of gearing, all of which is inclosed and protected from grit and water. The operator rides on the machine, his seat being located near the front or steering end, easily within reach of the motor controller and the steering and reversing handles. The machine is self-propelling in either direction at a rate of about 15 feet per minute.

There are six grinding wheels, each 13 inches in diameter, which rotate at a speed of about 200 revolutions per minute. They are arranged so as to entirely cover a track 33 inches wide. Each is held to its work by an independent adjusting screw; consequently the effectiveness of the grinding in no way depends upon the weight of the wheels. It is possible to raise any or all of the wheels so that they clear the floor if such a condition should be desirable.

This machine is built by the F. R. Patch Manufacturing Company, of Rutland, Vt.



AN ELECTRICALLY DRIVEN STONE FLOOR SURFACING MACHINE BUILT BY THE F. R. PATCH MANUFACTURING COMPANY, RUTLAND, VT.

THE HUTCHISON CARPET SWEEPER WITH THE COVER REMOVED. THE BALLS FOR BEATING THE CARPET ARE SHOWN AT EACH END OF THE BRUSH SPINDLE

A New Feeder Support

THE "Hercules" feeder support, manufactured by the Coleman J. Mullin Company, of Brooklyn, is placed upon the market to obviate the necessity of the complications which arise in endeavouring to support a heavy feeder, and also to conform to the rules and regulations of the National Board of Fire Underwriters. It is claimed that its great advantages can be appreciated only by those who have anchored large and heavy feeders at the points where they enter a panel-board, after rising from the switch-board in the cellar to the twelfth and fourteenth story of a modern office building.

A saving in both material and labour is claimed for this support, and a perfect hold is guaranteed. There is absolutely no fear of it ever slipping, for by the weight of the wire it

forms a gripping device to make a tighter hold.

This device can also be applied to securing a conduit instead of using pipe clamps. This advantage, it is claimed, will readily be appreciated by anyone who has had the experi-

INTERIOR AND EXTERIOR OF A NEW FEEDER SUPPORT MADE BY THE COLEMAN J. MULLIN COMPANY, BROOKLYN, N. Y.

ence of endeavouring to properly secure risers, in the very small space usually allotted to the installation, when it is known that the room required for the "Hercules" vertical conduit support is about 1 inch more than the pipe itself.

The sleeve, it is claimed, is a unique feature in itself, inasmuch as it obviates the necessity of the installation of an expensive pull-box, which occupies space and is difficult of installation, and at times offers the opportunity to decrease the insulation qualities of the installation very materially.

Blue-prints showing the dimensions, as well as illustrations showing the support in actual use, and other information will be freely given to those desiring it.

New Traction Facilities for Harrisburg, Pa.

EXCAVATIONS for the new power station of the Central Pennsylvania Traction Company, of Harrisburg, Pa., were begun early in December, and the construction of the building proper is now well on the way. The new plant adjoins the old No. 1 Station on South Cameron Street, Harrisburg, and, when completed, will replace three separate plants which are now in service. The building is 175 feet by 102 feet and one story in height, and is of steel construction embedded in concrete.

The steam and electrical equipment for the plant consists of three Reynolds horizontal cross-compound, condensing Corliss engines, heavy-duty type, built at the West Allis, Milwaukee, shops of the Allis-Chalmers Company. Each engine is direct connected to a 650-KW., 600-volt D. C. generator mounted on the main shaft, the generators also being furnished by the Allis-Chalmers Company and built at the company's "Bullock" works at Cincinnati.

These units have a capacity of 50 per cent. overload for short periods, giving a maximum capacity for the entire plant of approximately 4500 H. P. The main switchboard, which will consist of twelve panels, will be connected by a direct feeder line to each of the twelve different sections into which the Traction Company's lines are divided. The engine room will be 50 feet wide, extending the full length of the building, 170 feet, and directly facing Cameron Street. An electric travelling crane, with a lifting capacity of 30 tons, will serve the engine room for installing heavy apparatus.

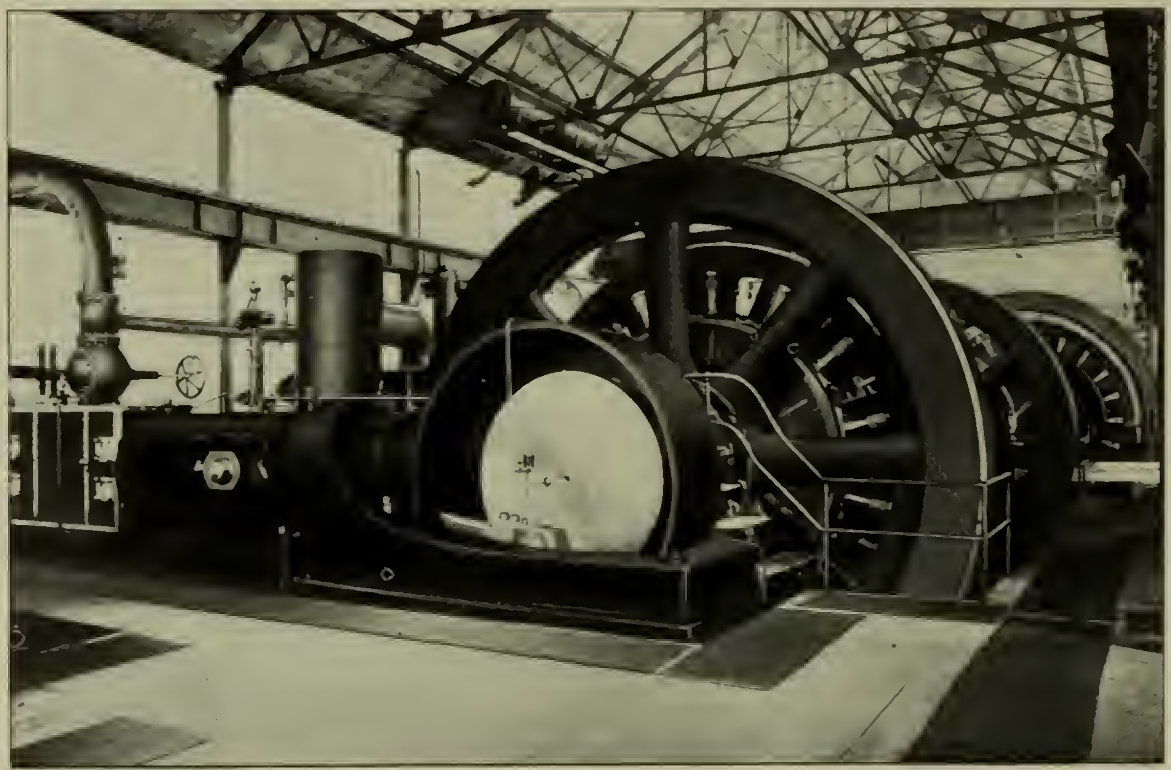
The boiler room, which will occupy the rear portion of the building, and contains, for the present, five 350-horse-power horizontal water-tube boilers furnished by the E. Keeler Company, of Williamsport, Pa., will be equipped with all the necessary modern appliances for handling coal and ashes, including an overhead bin for coal with 600 tons capacity. There will also be an overhead ash bin of ample capacity, the ashes being taken from the ash pits below the boilers in a basement 11 feet below the boiler room floor, and deposited in the bins by means of a vertical chain bucket elevator.

A continuous belt conveyor, extending the full length of the coal bin, is used for conveying coal to a bucket elevator. The boiler plant will be equipped with the usual feed-water heaters and economizers, which will occupy one-half of the floor space of the building only, ample room being provided for the installation of additional boilers and engines as the growth of the system warrants, so that the plant will have an ultimate capacity of nine or ten thousand horse-power.

The stack, 10 feet in inside diameter and 210 feet high above foundations, is built of reinforced concrete, resting on the solid rock 20 feet below the ground level. A railroad siding connecting with both the Pennsylvania and Reading Railroads will run between the boiler room and the stack.

An interesting engineering feature of the new plant will be the water supply tunnel. Plans have been drawn and the work will shortly be started on the boring of a 5-foot tunnel in the solid rock 30 feet below the surface of the ground, extending from the plant in a direct line under the yards of the Central Iron & Steel Company to the river. From the river bank a 36-foot cast iron pipe will extend to a point in the river where the best quality of water is to be obtained. This water supply tunnel will be built and used jointly by the Traction Company and the Central Iron & Steel Company.

All the work is being carried out from plans prepared by and under the direction of Mason D. Pratt, consulting engineer, of Harrisburg, and W. C. Gotshall and C. O. Mailloux, of New York City, acting as



THE EQUIPMENT OF THE NEW POWER STATION OF THE CENTRAL PENNSYLVANIA TRACTION COMPANY, HARRISBURG, PA., CONSISTING OF THREE DIRECT-CONNECTED UNITS, BUILT BY THE ALLIS-CHALMERS COMPANY

advisory electrical engineers. This plant, the cost of which will approximate $250,000, is expected to be ready for operation before summer.

Insulator Pins

THE Elmer P. Morris Company, of New York, have recently taken up the general sales agency for the Maine Hub & Manufacturing Company, of West Seboois, Maine, who have gone into the manufacture of insulator pins of every variety for electrical purposes. These pins, one of which is illustrated herewith, are made of the well-known black birch wood which has been used so successfully for the past forty years in making hubs for wagons and high-class carriages.

The Studebaker Company, of South Bend, Ind., used over 200,000 hubs made of this wood during the past year, and a large number were used by other carriage manufacturers, thus demonstrating that this class of material meets the requirements of very severe usage in the way of life and durability.

The Maine Hub & Manufacturing Company have thoroughly canvassed the trade and received the opinion of all the leading experts in wood throughout the United States, and they decided that black birch is equal, if not superior, to locust, or any other woods for this purpose. In consequence of this, they have established a pin department, and have been manufacturing since the first of the year about 30,000 pins a day. The electrical trade has examined these pins, and are specifying them, it is claimed, in preference to locust or any other wood.

For the convenience of the New York trade, a stock of 200,000 pins is carried in the store room of the Elmer P. Morris Company, 51 Dey Street, to fill emergency orders. Carload lots, however, will be shipped from the factory at West Seboois, Maine. The time consumed in delivering pins from the factory to New York or vicinity by rail and water is only about four days, so that purchasers who wish carload lots will be sure of prompt shipments. The mill aims to carry from three to four carloads of each size on hand at all times.

These pins are made in sizes from $1\frac{1}{4}$ by 8 inches to 2 by 14 inches, and with standard or $1\frac{3}{8}$-inch thread for high-tension insulators. The factory is equipped for boiling these pins in paraffine and linseed oil, and is prepared to also creosote them when so desired.

Samples of these pins will be mailed to all who are interested, by the Elmer P. Morris Company, 51 Dey Street, New York City, the general sales agents.

A sample of a sled runner made of black birch, which has been exposed to all kinds of weather for the past sixteen years, shows practically no deterioration, it is claimed, being perfectly sound and free from decay.

AN INSULATOR PIN MANUFACTURED BY THE MAINE HUB & MANUFACTURING COMPANY, WEST SEBOOIS, ME. THE ELMER P. MORRIS COMPANY, NEW YORK, ARE GENERAL SALES AGENTS

New High-Potential Insulating Compound

A NEW competitor of rubber for the insulation of wire and cable, is the high-potential insulating compound named "Voltax." It is manufactured by the Electric Cable Company, of New York.

Previous to exploiting this material commercially, it was subjected to a series of experiments extending over seven years, and later to some careful tests by the Electrical Testing Laboratories, of New York, more severe than the average working conditions under which it would be employed. The results of these experiments, so far as puncture, voltages, and resistance, are concerned, indicate, it is claimed, the superiority of this substance to rubber. In addition, "Voltax" is claimed to possess the advantage of being a neutral compound chemically, so that its qualities remain unimpaired by atmospheric conditions or the nature of the soil with which it is likely to come in contact. For the same reason, it is claimed to be an ideal material for insulating wires running through salt-water marshes, and has no corrosive effect on copper, so that it is unnecessary to tin the wire before applying the compound. Experiments made along other lines showed that this covering will not drip under 250 degrees, Fahrenheit.

Tests were carried out in the following manner: Four samples of wire were prepared, each wrapped with a different number of layers impregnated with "Voltax." The results detailed numerically in Tables I, II, and III were obtained with these wires, all of which had but a very thin wall of insulation. Of course, with additional taping, any desired puncture resistance could have been secured. All the high-potential tests were made by gradually raising the pressure of one or more transformers until the puncture occurred. Aside from the experiments on taped wires, the compound was also melted into sheets and tested between one-inch circular discs just touching either surface.

TABLE I

	Average Puncture Value Volts
One layer	4,399
Two layers	8,300
Four layers	27,750

The indifference of this material to salt water is shown by the fact that after 72 hours' immersion, a sample covered with one dry tape and six impregnated tapes presented a resistance of 23,000 ohms.

In Table II, a record is given of a high-potential test of two wires covered with impregnating tape, after a trial of their carrying capacity.

TABLE II

	Average Puncture Value
One-tape wire	2,050 volts
Four-tape wire	27,750 volts

The tests made on "Voltax" in sheet form are recorded in Table III.

TABLE III

Sheet		Volts at Puncture	Thickness	Volts per Mil
No. 1	Lowest	20,000	75 mils	267
	Highest	25,000	75 mils	344
No. 2	.....	*22,500	.....	
No. 3	.....	30,000	105 mils	286
No. 4	.....	30,000	.....	...

* Arced over edges but did not puncture.

In making the insulation resistance tests, a six-tape copper wire was used. This was immersed in salt water several times, and measured by the galvanometer method. The insulation resistance of the thin "Voltax" sheets was also measured. In both instances, the resistance was so enormously high, namely, in thousands of millions of ohms, as to make exact measurements impossible.

Trade News

The Westinghouse Machine Company, of East Pittsburg, during the months of February and March, received orders for thirty-five steam turbines aggregating approximately 50,000-B. H. P. capacity. The more important equipments were as follows:—Transit Development Company, Brooklyn, 7500 KW.; Toledo Gas & Electric Company, 3000 KW.; Los Angeles Pacific Railway Company, 2750 KW.; Detroit United Railway Company, 2750 KW.; Detroit United Railways, 1200 KW.; Columbia (S. C.) Electric Street Railway Company, 3000 KW.; St. Paul Gas Light Company, 1500 KW.; Grand Trunk Railroad Company, for St. Clair Tunnel, 3000 KW.; Detroit, Monroe & T. S. L. Ry., 1200 KW.; Northern Heating & Electric Company, St. Paul, 1000 KW., and Griffin Wheel Company, Chicago, 1000 KW. The largest is of 7500-KW. capacity, or 11,000 B. H. P, and will be installed by the Transit Development Company. It is of the well-known multiple-expansion, parallel-flow type, and will drive a direct-connected alternating-current generator, running at 750 revolutions per minute, developing 10,000 electrical horse-power at full load. By means of a secondary governor valve, with which all Westinghouse-Parsons turbines are provided, 12,000 KW. may be developed when running condensing, or full load when operating without condenser. This corresponds to a maximum capacity of at least 16,000 H. P. at the shaft. A number of machines of similar capacity are being built by the Westinghouse Machine Company for large power houses in New York, Brooklyn and other cities.

The new plant of the Electric Cable Company was formally opened at Bridgeport, Conn., on the afternoon of Monday, April 16. Refreshments were served by the officers of the company to members of the Bridgeport Board of Trade and to the neighbouring manufacturers, representatives of the press, and to employees of the company. The new building is a one-story brick structure occupying a space 62 by 230 feet on the corner of Crescent and Central Avenues. A space is provided for 300 employees and for 30 machines. The plant is equipped with a travelling crane, which carries the finished product to a platform erected on the north side of the building. From there the products will be loaded on the cars, which will be run from the main line of the New York, New Haven & Hartford Railroad over a private siding. It is the intention of the Electric Cable Company to erect further buildings on the large plot of ground at the west of the present plant. The company was incorporated in January of this year, with a paid-up capital of $500,000, which in the near future will be increased to $1,000,000. Its products include "Voltax," the new insulating compound, magnet wire, field and armature coils, and soldered mesh rails. Large orders have already been received from the Interborough Company, of New York, the Brooklyn Rapid Transit Company, and other large concerns.

The American Engineering & Construction Company has just been incorporated, with headquarters in the Eagle Building, Brooklyn, N. Y., by R. C. Taylor, Edward Taylor and J. J. Sides. The new company has included in its regular staff of engineers men of wide experience in the operation of electric railways, and is prepared to handle any class of mechanical, electrical and construction work. The company will also act as consulting engineers in drawing up or reviewing designs and specifications of complete plants, or apparatus to fulfil standard or special requirements.

The first message since the San Francisco earthquake from the representatives on the Pacific coast of the Crocker-Wheeler Company, of Ampere, N. J., was received at 9.15 Saturday morning, April 21. It was signed by one of the company's alternating-current engineers, and reads as follows:—"Crocker-Wheeler Company, Ampere, N. J. San Francisco ruins. Martial law. Could not wire sooner. Our stock total loss. Generators reported good condition; can see them Monday. No cars, water or light San Francisco. Express me, Wells-Fargo, Oakland, two hundred currency. Personal effects lost. Probably can leave upon receiving money. A. C. Bunker." The generators mentioned are three of the four 4000-kilowatt alternating-current Crocker-Wheeler generators recently sold to the California Gas & Electric Corporation for supplying current for the San Francisco street railway system. The plant in which these machines are installed is in a suburb of the city about seven miles from the heart of the business section.

The C. E. Hewitt Company, of New York, announces that, by an agreement just completed, its entire business interests will be merged in a new corporation, to be known as the Stevens-Hewitt Engineering Company, which will continue the business as heretofore, and will take over all existing contracts and liabilities of the C. E. Hewitt Company. The rapid growth of the business conducted by the C. E. Hewitt Company has made it necessary to enlarge its technical staff and to enlarge its facilities for financing the increasing number of important municipal and other contracts for installation of lighting and power plants that it is engaged in. All the members of the C. E. Hewitt Company will come into the Stevens-Hewitt Engineering Company, and the new members, Edwin A. Stevens, of Hoboken, N. J., and Irving Cox, of New York, are too well known for their business, financial and engineering ability to require any introduction.

The American Conduit Company, of Los Angeles, Cal., announces the removal on May 1, 1906, of its Chicago offices to more central and more commodious quarters in the Marquette Building, where A. L. Waterbury, general manager of the sales department, will be glad, as in the past, to receive the friends and patrons of the company, and where all inquiries by mail or otherwise will receive prompt and careful attention. The increase in the business of the American Conduit Company is decidedly gratifying and gives satisfactory evidence, both by the volume of business and the class of customers served, that the merits of Bituminized Fiber Conduit as an underground conduit have had practical demonstration and are being accepted with rapidly increasing favour.

The Allis-Chalmers Company, of Milwaukee, Wis., has received an order from the American Car Company, of Paulsboro, N. J., for a 20 and 42 × 42-inch horizontal cross-compound engine, direct connected to a 500-KW. engine-type electrolytic generator and a switchboard. The engine will run condensing at 135 pounds steam pressure and 100 revolutions per minute. It will be equipped with a special speed-changing device for varying the speed so that the generator voltage may be governed over a range of 100 to 200 volts. The generator will be a 14-pole machine, 500-KW., 200 volts. The shunt field coils will be so proportioned as to allow for increases in voltage between 100 and 200 volts, by approximately equal increments, by varying the speed of the engine and by rheostat, the output in

amperes being constant at 2500 throughout the range. Another large order is that from the Falk Company, of Milwaukee, whose steel foundries are among the largest in the State. They have recently purchased new equipment for the plant, consisting of a 20 and 42×42-inch Reynolds heavy duty, cross-compound Corliss engine, a 550-KW. direct-current engine type generator, an 18 × 36-inch steam, 30-inch steam × 18-inch air × 42-inch stroke Reynolds heavy duty, cross-compound air compressor; two Tomlinson barometric tube condensers, together with centrifugal pumps, boilers, switchboard, etc. Other orders are as follows:—The Atlas Portland Cement Company, Northampton, Pa., two 50-H. P. motors; the Hammerhill Paper Company, Erie Pa., one 150-KW. generator and one 175-H. P. motor; the Ellsworth Coal Company, Ellsworth, Pa., a 500-KW. rotary converter; the American Steel & Wire Company, Chicago, a 200-KW. generator; the Anderson & Middleton Lumber Company, Aberdeen, Wash., a 125-KW. generator.

Since last October the Koerting Brothers Company, Koertingsdorf, Germany, have closed contracts for seventeen 2-cycle gas engines, ranging in size from 300 to 2200 horse-power, to be installed in various parts of Europe. Several of these are repeat orders, showing the success with which the large gas engine is meeting in Europe. The American rights for these engines are held by the De La Vergne Machine Company, of New York. At the present time there are 157 Koerting 2-cycle gas engines, aggregating 131,685 B. H. P., in operation or in course of construction.

G. M. Gest, subway contractor, of New York, has obtained control of the Rundle patented graphic chart system for recording underground and overhead cable data. This system of charts has been adopted by the largest conduit users in the United States. A descriptive article was published in the April, 1904, issue of THE ELECTRICAL AGE. Further data regarding this cable chart and its uses can be had by writing to any one of G. M. Gest's several offices.

The Gas & Electric Development Company, of Philadelphia, has been organized to act as broker or agent in the purchase and sale of public service properties, such as gas plants, electric light and power plants, electric railways, waterworks, and the like. The company is also prepared to make reports on these properties from an engineering and a commercial standpoint, to act in a consulting capacity, or contract to do the work of construction, extension, or repair, and to operate, supervise, or manage them. H. C. Case is the president, A. B. Beadle, vice-president and engineer, and W. W. Levering, secretary and treasurer.

The Standard Underground Cable Company, of Pittsburg, have opened an office in the Candler Building, at Atlanta, Ga. C. A. Brown is in charge of the office.

The W. K. Palmer Company, engineers, of Kansas City, Mo., is the title of a new company organized to carry on the engineering practice and business conducted in past years under the name of W. K. Palmer, consulting engineer. The personal services of Mr. Palmer, as consulting engineer, will still be available as formerly, and other engineers will be associated with him in matters requiring expert services.

The Pittsburg offices of the Niles-Bement-Pond Company and the Pratt & Whitney Company, of New York, were recently removed to the Frick Building, Pittsburg.

The name of the Clark Insulation Company, of Boston, Mass., was recently changed to the Boston Insulated Wire & Cable Company. The ownership and management remain the same. H. B. Burley is the treasurer and manager. Their business is growing rapidly. In addition to regular "code" wire, solid, stranded, and flexible, they manufacture special wires such as used in automobiles and motor boats, also elevator cables, etc.

The Wagner Electric Manufacturing Company, of St. Louis, have completely outgrown their present quarters and have bought a tract of land 15 acres in extent just out of the city. They have engaged Dodge & Day, of Philadelphia, to make the layout, design buildings and select the necessary equipment. The preliminary layouts have been submitted and the buildings decided upon. Work will be started at once, and about one-third of the ground will be covered by buildings before the end of the present year.

A 600-H. P. Koerting gas engine, built by the De La Vergne Machine Company, of New York, is now being installed at the Clarksburg (W. Va.) works of the National Carbon Company, of Cleveland, Ohio. It will be used for general power purposes and will operate on natural gas.

The Manufacturers' Advertising Bureau, for many years on Liberty street, New York City, has removed to 237 Broadway. The bureau has been established since 1877, and has made a specialty of advertisements of machinery and engineers' supplies. Hereafter, it will also handle advertising for newspapers, magazines, and other periodicals.

The erecting department of the Westinghouse Electric & Manufacturing Company for Manhattan borough, New York, which, until recently, was located on the 19th floor of the Trinity Building, has been moved to the Fuller Building, corner of Twenty-third street and Broadway. This change was made necessary because the department was in want of more space than it was possible to obtain at 111 Broadway, and also because the uptown location is more suitable and convenient for the construction work, most of the power plants being located within easy reaching distance.

Recent engine orders booked by the Ball Engine Company, of Erie, Pa., are as follows:—Fruit Growers' Refrigeration & Power Co., Anna, Ill., one 200-H. P. engine; Central Ice Company, Mounds, Ill., two 150-H. P. simple engines; National Tube Company, Pittsburg, Pa., one 700-H. P. cross-compound Corliss engine; Burnham Brothers, Milwaukee, Wis., one 60-H. P. simple engine; Oliver Mining Company, Hibbing, Mich., four 100-H. P. single-cylinder engines; James W. Ellsworth & Co., Cleveland, Ohio, two 400-H. P. simple engines; Erie County Electric Company, Erie, Pa., one 70-H. P. center-crank engine; Norristown Electric Light & Power Company, Norristown, Pa., one 400-H. P. single-cylinder engine; Worcester Polytechnic Institute, Worcester, Mass., one 350-H. P. vertical cross-compound engine; Young & Summers, Lima, Ohio, one 350-H. P. horizontal cross-compound engine.

New Catalogues

Fan motors, manufactured by the Westinghouse Electric & Manufacturing Company, of Pittsburg, are illustrated and described in a very attractive booklet recently issued. The illustrations show the latest types of alternating-current and direct-current fan motors, and also installations in which floor, column, ceiling, desk,

and bracket fans are used. A bulletin also sent out treats of small power motors and their uses.

Machinery for rock-crushing plants is illustrated and described in a 72-page catalogue recently sent out by the Power & Mining Machinery Company, of Cudahy, Wis. Crushers, elevators, screens, and hoists are taken up in turn. A short description and a cut of the company's works at Cudahy are given in the first part of the booklet.

The preservation of ships by the "Long-Arm" system of electrically-operated water-tight doors is described in an interesting series of short talks incorporated in a booklet lately published by the "Long-Arm" System Company, of Cleveland, Ohio.

A new leaf for binding with the others previously issued by the Gisholt Machine Company, of Madison, Wis., has been sent out. On one side of this leaf is an illustrated description of a Gisholt 30-inch vertical boring mill, and on the other side is shown a power-moving device for the rapid traversing of the turret slide on Gisholt lathes.

The Schaeffer & Budenberg Manufacturing Company, of New York, have sent out a new catalogue, showing a complete assortment of their products. These include steam gauges, cocks and siphons, hydraulic pumps for testing gauges, vacuum gauges, anemometers, hydrometers, sachrometers and thermometers, pyrometers, water gauges, water alarms, safety valves, steam injectors, indicators, counters, tachometers, oil cups and grease cups.

Personal

General Eugene Griffin, first vice-president of the General Electric Company, sailed from New York on April 10, on the steamer "Graf Waldersee." General Griffin has planned an extended trip in England and on the Continent, largely for rest and recreation. As he is a director in the Cie Francaise Thomson-Houston and vice-chairman of the British Thomson-Houston Company, these interests will naturally claim a portion of his time.

George R. Metcalfe, editor of the "Technical World Magazine," and also of the text-book department of the American School of Correspondence, Chicago, has resigned to accept the position of editor of the publication department of the Westinghouse Electric & Manufacturing Company, at East Pittsburg. His experience in the field of technical journalism will make him eminently fitted for the position.

Prof. Pierre Curie, who, with his wife, discovered radium, was run over by a wagon and killed in Paris on April 19. He was born in Paris in 1859, and began scientific researches on his own account when twenty years old. He was assisted by Marie Slodow Slodowska, whom he afterward married. Radium was discovered during experiments with the salts of uranium. In December 1903, Professor and Madame Curie received the Nobel prize for chemistry, and a few weeks later they received 60,000 francs, part of the Osiris prize of France,—all in recognition of their great services in the discovery and application of radium. M. Curie refused the red ribbon of the Legion of Honor, which was offered him by the Minister of Public Instruction in 1904.

C. Frank Schwep has been appointed general purchasing agent of the Ingersoll-Rand Company, with headquarters at 11 Broadway, New York. Mr. Schwep has been at the head of the purchasing department of the Ingersoll-Sergeant Drill Company for the past thirteen years and was located at the shops at Easton, Pa., and Phillipsburg, N. J.

Frank H. Taylor has severed his connection with the Westinghouse interests, of which he has been for the past eight years one of the most prominent officials, especially as the vice-president of the Westinghouse Electric & Manufacturing Company in charge of commercial operations. He proposes to enjoy a well-earned rest after his extremely active life of recent years, before taking up any new line of work. His many friends will wish him a thoroughly enjoyable vacation and welcome his return to active business.

N. D. Macdonald, of the Electrical Testing Laboratories, of New York, is at present dividing his time between the works of the Locke Insulator Manufacturing Company, at Victor, N. Y., and those of the R. Thomas & Sons Company, at Lisbon, Ohio. He is engaged in inspecting and testing high-tension insulators for several transmission plants in the West.

Lemuel Bannister, for many years vice-president of the Westinghouse Electric & Manufacturing Company, of Pittsburg, died, April 13, at the Hotel Imperial, New York City, after an illness of several months. Mr. Bannister was born in a small town in Northern New York in 1841. His first business ventures were in the lumber trade, and for many years he was connected with R. DeWees Wood in that business in Philadelphia. Then he went into the electrical business, becoming connected with the Westinghouse Company. He was vice-president of the New York house and practically at the head of the European business. To take charge of the latter he left America ten years ago. He built the electric railways in Berlin and other European cities. He was also in charge of the Pittsburg house for a time. He was a member of the Lawyers and Engineers clubs, of New York, and the Duquesne Club, of Pittsburg.

George H. Rowe is now associated with W. Owen Thomas, consulting engineer, First National Bank Building, Chicago. After graduating from the University of Michigan in 1891, Mr. Rowe successively held the positions of instructor in electrical engineering at that university, professor of physics at Colorado University, designing engineer with the General Electric Company, professor of electrical engineering at Leland Stanford University in California, and designing engineer with the Western Electric Company at Chicago. He has contributed largely to the technical press, is a member of the American Institute of Electrical Engineers, and of the Society for the Promotion of Engineering Education.

D. H. Wilson, Jr., formerly of the American Locomotive Company, has been appointed to fill the newly created office of electrical engineer of the Erie Railroad, in charge of the power plants and other electrical equipment along the entire system. He will devote himself at first to the work of equipping the Erie Railroad Company's power house at Hornellsville, N. Y. After serving a four years' apprenticeship in the Rogers Locomotive Works at Paterson, N. J., Mr. Wilson studied electrical engineering at the Bliss School in Washington, and then graduated from Purdue University. Before his connection with the American Locomotive Company, he was associated with J. G. White & Co.

L. A. Osborne, formerly third vice-president of the Westinghouse Electrical & Manufacturing Company, was elected second vice-president at a recent meeting of the board of directors, to succeed Frank H. Taylor, resigned. Mr. Taylor, who is

also a director of the company, will retain his seat on the board. Mr. Osborne, as third vice-president, had the direction of the engineering and manufacturing activities of the company. As second vice-president, he will assume the direction of the commercial activities of the company while retaining those of the engineering department. The new second vice-president is a graduate of Cornell University. He entered the employ of the Westinghouse Electric & Manufacturing Company in 1891, and has successively held the positions of assistant superintendent, assistant to the vice-president, manager of works, fourth vice-president and third vice-president.

Frederick W. Taylor, president; Prof. F. R. Hutton and Fred J. Miller are the members of the special committee of the American Society of Mechanical Engineers appointed to suggest a candidate for the secretaryship of the society, Prof. Hutton having resigned that position.

L. F. Bower, formerly manager of the electrical works of the Allis-

L. F. BOWER

Chalmers Company in Cincinnati, and recently promoted to the position of comptroller of the company, has already assumed the duties of his new office, with headquarters at the general offices of the company, Milwaukee. Previous to his association with the Allis-Chalmers Company, Mr. Bower was secretary and treasurer from 1896 to 1901 of the Dickson Manufacturing Company, of Scranton, Pa., manufacturers of locomotives and all kinds of heavy machinery. When the machinery department of this concern was absorbed by the Allis-Chalmers Company in 1901, he was retained as manager of the Scranton plant until 1904. On April 1, 1904, he went to Cincinnati as secretary and treasurer of the Allis-Chalmers Company's electrical department, and in 1905 was appointed manager. While at Scranton, Mr. Bower studied law and was admitted to the bar of Lackawanna county.

Changes in Westinghouse Personnel

On account of the rapid expansion of the business of the Westinghouse Machine Company, of Pittsburg, the board of directors has decided to enlarge the executive organization by increasing the number of vice-presidents from two to four, and has elected E. H. Sniffin and Arthur West to fill the new offices of third and fourth vice-president, respectively.

Mr. Sniffin will be in charge of the sales department, as heretofore, his field of work not being altered in assuming the new title. Mr. West, who has been chief engineer of the company, still retains that title and position.

William A. Bole, in consequence of his election to the vice-presidency of the Westinghouse Foundry Company, has resigned his position as manager of works of the Westinghouse Machine Company, in order that he may better serve the interests of the Foundry Company, of which he assumes the entire management. The Westinghouse Machine Company, however, retains Mr. Boles as consulting engineer, availing itself of his services and counsel on important work, which his ripe experience has made peculiarly valuable.

Henry L. Barton, formerly general superintendent of the East Pittsburg works of the Westinghouse Machine Company, has been appointed manager of works.

In discussing Franklin as a man of science and an inventor, Dr. E. J. Houston said, recently, that one of his contrivances was the electric jack, an ingeniously constructed electrostatic motor that was capable of rotating, even when loaded with a turkey properly prepared for cooking and placed before a fire. It was this apparatus that Franklin refers to, in a letter dated April 29, 1749, as follows:—"A turkey is to be killed for our dinner by the electrical shock, roasted by the electrical jack before a fire kindled by the electrical bottle."

Henry Rustin

BY W. M. PROBASCO

On the twenty-seventh of February last, Henry Rustin, a man of charming personality and an engineer of ability, passed away in the town of Florence, Neb. Rustin was always friendly in manner, candid in speech, modest but persistent, loving and gentle in his family, and thoroughly informed.

He planned and executed the principal engineering features of the Trans-Mississippi Exposition, the Greater America at Omaha, the Pan-American at Buffalo, and was chosen to be chief electrical and mechanical engineer for the Louisiana Purchase Exposition at St. Louis. It was to

HENRY RUSTIN

his desire to make this the crowning glory of his career that he sacrificed his life.

The week of the dedication in St. Louis was wintry, and Rustin, working day and night in the service of the Exposition, contracted a cold that affected his lungs and resulted in his death. His physicians told him to abandon his work, but this he refused to do until his plans were completed. He then gave up temporarily and went to the Adirondacks, only to return just before the close of the Exposition to see the fulfillment of his plans.

Rustin was born in Omaha, Neb., September 4, 1865. He was the son of Captain Charles B. Rustin, one of the pioneers of Omaha, who helped raise the city from a frontier hamlet to its present position of prosperity and influence.

Henry entered the public school, and early developed a deep interest in chemistry, mathematics and me-

chanics. From the High School he went to Philip's Academy, at Andover, Mass., and graduated from the chemical and electrical departments in 1883. Thence he went to Yale and graduated from the Scheffield Scientific School in 1886. He then returned home, where he was engaged as a bank cashier, only to await a suitable opening. The opportunity came a year or two afterwards when he was engaged to convert the horse-car system into electric traction in the city of Portland, Ore.

He was twenty-three years of age at that time. Within a few years he had wired the city, built three power houses, and increased the street car mileage from three to fifty miles. His work here was a splendid accomplishment at that comparatively early period in the history of practical electrical engineering.

In 1893 he resigned his position at Portland to assume the management of the Hazelton Manufacturing Co., who were then changing from steam to electricity. Upon the completion of this work, Rustin was selected to take charge of the electrical work in connection with the Trans-Mississippi Expositicn, and the following year he was elected superintendent of the Greater America Exposition.

At this time the Pan-American was being organized, and Rustin was selected for the management of its electrical work. During its progress there were many large and important contracts placed with leading manufacturing establishments for apparatus involving special design and expert engineering talent.

He was largely responsible for the design of the apparatus for gradually raising and lowering the voltage for the lights at the Pan-American. This made possible a brilliant lighting effect, and was one of the features of the Exposition. Rustin's experience, then, along these lines made him the logical man for the post of chief electrical and mechanical engineer for the Louisiana Purchase Exposition.

During the past year Rustin located in Denver, where he engaged in special engineering work for the Denver Electric Lighting Company, and later went to Florence, Neb., and was appointed chief engineer of the Omaha waterworks.

Henry Rustin faithfully discharged every trust and obligation. In the award of large contracts, that meant competition and large expenditures, his judgment was guided by absolute fairness and reason. No man ever attempted to influence him more than once.

Two weeks before his death, he was told that the end was near. He fought hard to live, for he felt that he had not done his best work. He was tender and just, where others were harsh and vindictive, a loving husband, a good father, and a generous man. The writer knew him for many years, and has yet to hear a word spoken of him except in praise.

April Meeting of the New York Electrical Society

THE New York Electrical Society held its 258th meeting at the Edison Auditorium, 44 West Twenty-seventh Street, Wednesday, April 25. The address of the evening was on "News, Newspapers and the Telegraphic Art," by Melville E. Stone, general manager of the Associated Press. In view of the interest in the disastrous earthquake and fire at San Francisco, the officers of the society supplemented this with special addresses bearing on the catastrophe.

President Barstow gave a sketch of the remarkable power transmission development in California, for which San Francisco is the focal point, and Dr. F. A. Perrine, speaking on the same subject showed on the screen some of the most interesting points of these installations, together with many of the buildings in San Francisco which have been destroyed. Mr. Stone gave a lucid and eloquent exposition of the development of news gathering and of the extraordinary achievements which telegraphy now renders possible.

The following members were elected:—Charles N. Green, A. E. Mitchell, Alex. Cameron, Frederic A. Coolidge, Arthur M. Huntington, Leigh S. Keith, Ainslie A. Gray, Dr. Emil Heuel, S. S. Dickinson, C. B. Fairchild, Jr.

A new instrument for surveying deep bore-holes contains a compass, plummet, cameras and electric light, the whole connected with a small adjustable clock, so that the light may be turned on for a given period after the apparatus has been lowered into the hole. It has been used in surveying a number of holes in South Africa and has proved satisfactory. Both dip and deviation are recorded by means of photographs of the positions of both a plumb-bob and a magnetic needle at any desired point in the bore-hole. The photographs are taken by means of two small electric lamps lighted by a time contact.

Preparations for the Atlantic City Convention of the National Electric Light Association

TO begin the preparation for the convention of the National Electric Light Association the first week in June, Arthur Williams, chairman of the convention committee, and T. C. Martin, chairman of the committee on progress, visited Atlantic City recently to make preparations and lay out carefully a large amount of preliminary work.

As is already known, Young's Pier has been engaged for the week, and the exhibit and meetings will all be held there, right over the ocean, and cooled by sea breezes. A spacious hall provides for the main exhibits, and already very little space is left, owing to the great demand, so that an overflow into the pier wings is probable.

The exhibit of central station advertising material, by the committee on progress, also promises to be very large and to embrace a number of new features. This will be given in an adjoining hall, on the way to the convention meeting place, further down the pier, which is of considerable length and width.

The uniform plan of exhibit, decoration and booth, is found to lend itself admirably to the space provided, and the lighting and colour scheme will prove very effective. While the convention is going on, there will be in full swing on the pier, without any interference, concerts by an excellent band, a vaudeville theatre, a skating rink, and net deep-sea fishing, so that the variety of instruction, entertainment and amusement will be something never enjoyed before or under such favourable conditions for comfort. Inquiry brought out the fact that the reservations at the thirty-seven hotels on the association list are already very large, running up into the hundreds.

There were 16,138 wells producing natural gas in the United States at the close of 1904. These vary greatly in depth and production. Some of the more shallow wells are only 250 feet in depth, while the deep sand wells in southwestern Pennsylvania and in West Virginia are in many instances over 3000 feet in depth.

What is said to be the largest and highest concrete steel chimney in the world, was recently completed at the Butte (Mont.) Reduction Works. The height is 333 feet 4 inches.

Some Practical Experiences with Steam Turbines

By C. E. STANTON, Chief Engineer, Union Electric Co., Dubuque, Ia.

From a Paper Presented at a Recent Meeting of the Iowa Electrical Association

THIS paper is based on the everyday practical experience of the writer, as encountered in the erection and operation of Curtis four-stage, 500-KW. turbines.

STEP-BEARING PUMPS, BAFFLERS, STRAINERS, ETC.

All step-bearing water passes first through a "Jewel" water filter, thence through the pumps to the strainer which is contained in the "baffler casting,"—thence through the baffler direct to the step bearing. By its passage through the baffler, the pressure of the water is reduced, so that (in this case) the actual step-bearing pressure is from 180 pounds to 200 pounds per square inch. All shock or pulsation of the step-bearing pumps is also eliminated by the baffler.

As the step pumps and the service pumps, which supply the water used in the step-bearing pumps, are packed with a fibrous packing, we soon found that we must keep a record of the safe life of this packing,—as, if it were left in until it began to lose its elasticity and get soft, small particles and strings of packing would find their way into the strainers, and would soon plug them, thereby cutting off the water supply to the step.

We find that on the step pumps, which pump against a pressure of 400 pounds per square inch, the safe life of the packing is sixty days. On the service pump, against 50 pounds pressure, the safe life of the packing is four months to five months, depending on the condition of the river,—whether muddy or not. We find that if dirt or pieces of packing do get into the step-bearing pipe system, it is uncertain when they will find their way into the strainers,—it may be hours, days or weeks.

This uncertainty is far from pleasant, because if there is enough loose packing in the system it can at any time plug the strainers, thus cutting off the water supply to the step bearing. All strainers are taken out and cleaned every twenty-four hours.

The hydraulic accumulator, which is connected into and forms a part of the step-bearing piping system, and which acts as a reserve in case of the temporary stoppage of the step-bearing pumps, is tested every twenty-four hours. To test the accumulator, the throttle on the step-bearing pump is closed slightly, as we run the step pumps just fast enough to keep the accumulator up.

This slight closing of the pump throttle allows the accumulator to drop slowly. We lower it 4 or 5 feet every day. As there are always one or more turbines in operation, and as we carry just pressure enough (400 pounds) on our step-bearing pumps to keep the accumulator raised, if it was not for the test each day, it would always be up and would finally rust fast and would not come down, even if all pressure were removed from the pipe system which holds it up,—thus defeating the object for which the accumulator is used.

We know by experience that the accumulator will stick, if not tested often. The ram or piston of the accumulator is 9 inches in diameter, and the bored part of the cylinder, which acts as a guide to steady the accumulator when raised, is about 36 inches in length. As this bored part is a close working fit on the ram and the water is always in contact with it, the nicest kind of a rust joint will finally form between the ram and the bored hole around it.

One other precaution, which is usually taken in connection with accumulators for this work, is some kind of signal, usually a steam whistle, which will blow if the accumulator starts to come down. Something of this kind is necessary, as, without it, if the step pumps should slow down, and there are many reasons why they should do so, the step pressure might get so low as to be dangerous and injure the step.

STEP BEARINGS

As the step bearing, with its very thin film of water under pressure, has to support the weight of all the revolving parts of the turbine, wheels, shaft, field, etc., it is a very important part, and cannot be examined too closely while being assembled. Under the bottom half of the step bearing is the adjusting screw; this screw is vertical and in exact alignment with the turbine-shaft centre. The end of this screw, on which the step bearing and all the revolving parts of the turbine are carried, must be exactly square with the axis of the screw,—a burr or dirt here means trouble, as it will throw the step out of its true alignment.

This is also true in regard to the top of the upper step plate and the bottom of the turbine shaft, which rests in a socket or recess in the top of this plate. In the bottom of the turbine shaft are drilled two guides or dowel-pin holes. A keyway is also cut across the bottom of the shaft, the guide pins and key are made fast in the top of the upper step-bearing plate, and are an easy fit in the shaft,—if all surfaces are clean and all burrs, scratches, etc., removed.

If through any cause the step plate should bind, either from dirt, abrasions, or a bad fit, and it should be forced up in place, the chances are that it would not be square with the shaft. The turbine would then have a tendency to vibrate, and might not run right until this fault was corrected. The bottom step-bearing plate should be an easy fit in the casting which holds it and the adjusting screws in place; it should drop of its own weight into its socket or recess, and should not bind or have to be forced to its seat.

Both step plates should be of exactly the same diameter and should line perfectly. The recess in the plates, from which the step-bearing water is forced out between the faces of these plates, should also be of exactly the same diameter and depth. The edges of the recess should also line perfectly, as if they were not in line a fin might form around one side of the recess, which would cause an unequaled flow of water from the step and have a tendency to cause vibration.

If for any reason it is desired to grind the step bearing in place, it can be done very easily, and without any trouble whatever by gradually closing the stop valve between the step-bearing main pressure pipe and the step bearing. By listening at the step bearing and watching the step-bearing gauge while very slowly closing the stop valve, any degree of pressure can be had between the two bearing faces of the step. It should be borne in mind that the greater the speed of the turbine while grinding the step, the faster the faces will grind, and the more damage would be done if the stop valve was closed enough to let the steps together hard.

STEADY BEARING

Directly above the step bearing is the steady or guide bearing. This is a bronze shell, flanged on one end, lined with babbitt metal, and bored about 0.006 inch larger than the shaft. It is held in place by stud bolts through its flange; these studs

are screwed into the bottom of the turbine base. The outside of this sleeve is tapered and fits in a corresponding tapered hole in the base of the turbine.

Before this bearing sleeve is put in place, it should be thoroughly cleaned and examined for any rough spots. If it should not seat perfectly all around when in place, it will work loose; screwing up on the nuts will not hold it. We have had two or three loose steady bearings, and in each case the trouble was found to be due to dirt, bruises or metal chips, which would not allow the bearing to seat properly.

Before leaving the subject of bearings, I want to say that the first turbine started in our plant, and which has done all of its share of the work since (about one year), has the original step bearing and guide sleeve still in place, and apparently as good as ever.

TURBINE PILOT AND MAIN NOZZLE VALVES, ETC.

There are eight main nozzle valves, each with its individual pilot valve, which is electrically controlled. The pilot valves control the action of the main-nozzle valves. On any load within the rated capacity of the turbine, running condensing, five valves are all that will open, leaving three valves which might not open for days at a time.

If these valves are left alone they will corrode and stick, and if a heavy overload should come on, might not open at all,—or if they did open, they might stick open. In this case, if a short-circuit should open the breakers, the turbines would run away, causing the safeties to act and shutting off the steam supply to the turbines. This would cause considerable more delay in getting current back on the line again. If the main valves are packed too tight, or if the pilot valves leak, the main valves may stick.

To obviate these troubles all valves are opened and closed several times each day when starting turbines. As the pilot valves are electrically operated, and as they govern the action of the main-nozzle valves, all that is necessary is to make or break the electrical contact for each valve, which, if kept in proper condition, will open and close promptly.

The close regulation of the turbines was a surprise to some of us who had spent many years in charge of belted and direct-connected engines and generators. It was the original intention to use separate turbines and bus-bars for the commercial lights, but this has not been found necessary. Everything we have,—railway, power, and lighting,—is on one set of bus-bars. We have no trouble with the regulation of lights or turbines.

A suitable packing for the main nozzle valves was at first hard to find. We first used a kind of string metallic packing which has proved successful on lower steam pressures, but found it would melt here, as 190 pounds of steam and 150 degrees of superheat were too much for it. We then tried another kind of metallic packing, guaranteed to stand any degree of superheat. This seemed to be made up of small metal chips and graphite, and was supposed to form a well lubricated metallic ring which would last for months.

In use, however, the chips of metal would get under the pilot and main valves, holding them open. All valves had finally to be taken out and cleaned. In cleaning the stuffing boxes all that was found of the packing was a lot of loose metal chips. We now use the best asbestos ring packing we can get, and pack the valves more often than we expected to with the metallic packing.

MIDDLE AND TOP BEARINGS

The middle bearing is made in halves of cast iron, babbitted and bored out about 0.01 inch larger than the shaft. Extra large oil grooves are cut in both middle and top bearings. They run in a bath of oil, and with a circulation of oil through the bearings more than would be possible with any other type of the bearing with which the writer is familiar. The top bearing is a cast-iron shell flanged on one end, babbitted and bored about 0.01 inch larger than the shaft; it is clamped in place by bolts through the flange, if it is a solid bearing.

We have used both solid and spring bearings for the top and middle bearings. At first all bearings were solid; at present both top and middle bearings are of the spring type. On two turbines the springs have been renewed several times; on one, once or twice; on the fourth, or rather the first one supplied with spring bearings, the first bearings put in are still in use,—it is about six months since these bearings were first put in.

LUBRICATION

Gravity oil feed is used on all turbines, and the bearings are so constructed that there can always be a strong circulation of oil.

One trouble we had can be best explained by first giving the layout of our gravity oiling system. From the turbines the oil flows by gravity to the oil-cooling and separating tank, then through the oil filter to the suction tank, from which the oil pumps take the oil and pump it into the gravity-oil-feed tank, which is perhaps 25 feet above the turbines. From this tank the oil flows to the turbines, then to the cooling tank, and thence through the filter, etc.

A valve cuts the oil off from the gravity-oil tank and puts the full force of the oil pumps on the oil-feed line. This valve proved to be our salvation several times before we learned where our trouble was. With three or four turbines on, the oil would suddenly stop running on the turbines. The only thing left to do was to partially close the valve on the delivery pipe to the gravity-oil-supply tank, putting the oil pump directly on the oil-pipe system, when, of course, the oil had to come if the pumps were in order.

It was finally decided that air must trap in the gravity-oil tank, and getting into the oil-feeder-pipe line interfere with the flow of oil. This would cause an intermittent flow at certain times, of which we had no means of knowing until we found our supply of oil shut off. That this was right has since been proved by the remedy, which was to vent the top of the tank. We used a ½-inch pipe, 4 or 5 feet long, with the top bent in the form of a goose neck.

One point in regard to the step-bearing pumps which was overlooked by the writer and should have been mentioned in its proper place, is concerning the water valves. After nine months' service it was noticed that the pumps were running much faster than at first, to do the same amount of work. An examination showed that the water valves and seats were cut quite badly, and nearly all the way around with shallow grooves, mostly, although some spots looked, as far as their shape was concerned, more like corrosion than anything else. We made a tool to true up the seats in place and faced the valves off in a lathe; with a slight grinding with emery dust we had them in good condition again.

It was thought that as these valves should open and close positively with each stroke of the pump, they should not cut so quickly or as badly as they did. Close examination showed that a close hard scale had formed on all valves and seats, and this seemed to hold the valves slightly away from their seats. This wire drawing of the water (if it can be so called) was thought to be the principal cause of the cut valves. We now clean them free from this scale each week.

Modern Methods of Advertising

By FRANK B. RAE, Jr.

From a Paper Read before the Iowa State Electrical Association

YOU have heard a great deal within the last few months on this subject of advertising. The technical press has been full of it. Advertising agencies have bombarded you with it. In your personal meetings and conventions you have discussed and argued it. Advertising, in short, is the talk of the hour among electrical men,—the fad. "Where will it all lead?" you ask.

Gentlemen, it will lead to this:—The business of manufacturing and marketing electric current will become as other business, and it will be advertised as other business. The trouble just now is that central-station policy and practice is changing to meet new conditions. Heretofore business has come to you. Hereafter you must seek business. That is the meaning of all this furor.

Advertising, when stripped of its trappings and gilt, is a very plain, common-sense business proposition,—a proposition of selling goods. While it would seem that this is simple enough and obvious as the first proposition in geometry, it is a fact that only a very small percentage of so-called advertising conforms to this definition. On the contrary, the fundamental principle has been so hidden and befogged by a maze of high-sounding words that not one man in a thousand of those who foot the bills knows what he is trying to accomplish or is paying others to accomplish for him. He staggers along blindly, believing that any sort of an announcement regarding his business is advertising, and the more startling the form and wording of this announcement the better advertising he believes it to be. Just as idol-worshipers of old clothed their religion in fearful mystery and expressed it in awe-inspiring pageantry and ritual, so the advertising man of to-day shrouds simple truth in a garment of the inexplicable and says much about nothing, with pomp and ceremony.

Gentlemen, there is just one mystery in advertising,—the mystery of the personal equation. Advertising,—real advertising,—is good or bad only as the man who prepares it is gifted or not gifted. Words are in every man's mouth, but every man cannot be a Patrick Henry. A pen is in every man's hand, yet every man is not a Shakespeare. The tools of advertising are within every man's grasp, yet very few men can write an effective advertisement. It is well for us to recognize at once that the gift to see and express in advertisements the possibilities of a business is no more common than the gift to see and express in poetry the inspiring beauties of nature.

Advertising has been likened to salesmanship. Salesmanship-on-paper is the expression of a clever advertising man. For practical purposes this is a very good definition. Furthermore, it bears out what I have already said. You have all listened to the clever salesman. He came unknown, unasked, and unannounced. His dress and appearance were his credentials; a bright word his introduction. In terse, clean-cut English he told his story; with convincing logic he drove home his argument; with undeniable assurance he solicited your business. Tact, courage, good breeding stamped each word. If he did not get an order he left an indelible impression of the worth of his goods. Perhaps you did not want to buy them,—for any one of a thousand reasons,—but sooner or later his well-delivered arguments, his tactful insistence, will win you. You will buy.

What were this salesman's qualifications? He was tastefully, or at least decently, dressed; his introduction commanded your attention; his argument appealed to your reason; his tact and cleverness assured him a future opening if not an immediate sale. These are the qualifications of a successful salesman. They are the qualifications of the successful advertisement.

My paper was to have been devoted to advertising methods, yet I have spoken only of advertising matter. I have done this with purpose, for unless the matter is right, no method will avail. Results of a sorry sort will come from almost any advertising, just as sales will be made from almost any salesman; but if you are to enter this field with an idea of profit, let me exhort you to pay the bulk of your attention to matter. The need of method will be self-evident.

It must be understood that the backbone of your business-getting department is the solicitor. Advertising can persuade a man of the advantages of your service; can convince him that he needs it; can crystallize his desire into an immediate demand for specific information touching his individual wants; but it cannot figure his installation, nor secure his signature to a contract. This requires a solicitor.

Granted that you have intelligent and energetic solicitors, the advertising will be designed to bring the prospects to the point where it will require the least amount of the solicitor's time to close a contract. To do this is not the work of a single advertisement, nor of a number of diversified and disjointed advertisements. It is the work of a long-continued, regular, systematic advertising campaign.

It is here that the average lighting manager interposes objections. He is perfectly willing to take a "flyer," to send out three or four mailing cards, perhaps, or insert a so-called "catchy" ad. in the newspapers. Such advertising, if advertising it can be called, is the sheerest waste of money. Object as you will to this statement, if you but compare again your advertising campaign to the work of the accomplished salesman you will begin to see the "reason why" of the follow-up method. For your salesman does not always get an order on his first call, nor his second, nor the third. It may take a half dozen of his calls to educate you to the advantages of his goods and to win your confidence,—in short, to bring you to the buying point. Had the firm employing this salesman sent a different man each time, had the various men employed radically different methods, it is probable that you would pay little, if any, attention to their solicitations. But the one man, the one method,—the constant, aggressive, persistent, follow-up,—that is what lands the order.

And that is what will land orders from advertising.

The matter of such a follow-up campaign should be planned, prepared and systematized in advance with very strict regard to local conditions. It is in the planning and systematizing that such a campaign wins or loses,—in the logical sequence of the advertising used. The system of handling inquiries, of checking and revising the mailing lists, of adapting the solicitor's labour and reports to the mutual benefit of both solicitors and the advertising,—these are all vitally important points to be settled before a single piece of matter is issued. Having settled them, the actual follow-up work resolves itself into the very simple proposition of seeing that the matter goes out promptly on the

scheduled dates, that inquiries are carefully followed, and that the enthusiasm of the soliciting force is kept at fever heat. When it is understood that the chief object of the advertising is to pave the way, introduce and make definite appointments for the solicitors, the importance of having the latter always aggressive will be appreciated. The actual business-getting must, and always will, remain with the soliciting force.

"Modern Methods of Advertising," so far as the central station is concerned, means merely that you regularly and persistently keep the advantages of your service before every prospective customer within reach of your mains. That such methods can be adopted with profitable results by the smaller plants has been demonstrated.

But a warning should be sounded. Do not make your advertising too elaborate or too voluminous. Do not waste it upon ill-chosen lists. Most important of all, do not allow it to be designed by an advertising man ignorant of the ethics of the lighting business, or by a lighting man lacking in advertising genius and experience.

Electric Motors for Machine Driving

IN a paper on "Some Common Errors in the Use of Electric Motors for Machine Driving," recently read before the Institution of Engineers and Shipbuilders of Scotland, W. A. Ker points out that if a series motor and a shunt motor are designed for the same maximum load, current, and speed, then at smaller currents the shunt motor will have the larger torque, since its field remains constant, whilst that of the series-wound machine falls off as the current is reduced.

The not uncommon statement that the torque of a series-wound motor varies as the square of the current is also, he remarks, incorrect, save for a particular region of the saturation curve; and in current practice the torque of such motors varies at much the same rate as the current for a large proportion of the curve of torque.

With machines built twenty years or so ago, the statement objected to was nearly correct, since the magnetic induction was far from saturating the iron, and hence any change in the current gave rise to a nearly equal change in the strength of the field. With modern motors, where the magnets and yokes are nearly saturated, this is not the case. Mr. Ker, therefore, suggests that when a motor is needed for practically constant speed and constant torque, though not necessarily full-load torque, a shunt-wound motor should be used.

The same type should also be employed for constant speed and varying torque, whilst, where the conditions call for approximately constant speed and varying torque, subject to sudden overloads, the advantage rests with compound winding; when, however, the motor is required to work at varying speeds with a torque varying inversely as the speed, the series motor should be used; but if varying speed and constant torque is required, the shunt-wound motor, regulated by varying the resistance of the field-windings, is called for.

Water-Power in Switzerland

IT is calculated that in the course of a few years, says "The Electrical Review," of London, the Aluminium Industry Company, of Neuhausen, will have about 85,000 H. P. available for use, as the company already obtains 25,000 H. P. from its three works, and large extensions are in progress. These latter comprise the utilization of the waters of the Rhone and the Navigence, which are to be led separately by tunnels and mains to a point near Chippis, in the neighbourhood of the Sierre station, where two turbine plants are to be installed for the concentration of the resulting 50,000 H. P. in a single works.

The Navigence scheme, which is the first to be carried out, has been arranged for under contracts, whereby the firm of Escher, Wyss & Co. will deal with the double pipe line and turbine installation comprising ten units, yielding a minimum of 25,000 H. P., while the electrical generators, etc., will be furnished by the Oerlikon Machine Works and the General Electricity Company, of Berlin.

It is proposed to follow with the Rhone scheme in the summer, and it is expected that the power realized will be approximately the same as in the preceding project, and in both cases the cost of the power will be very low.

The third extension is that relating to the utilization of the Rheinau, which will yield about 10,000 H. P., although the cost per H. P. will probably be higher than in either of the former cases. It is also intended to carry out this scheme at an early date.

The World's Rubber Production

ACCORDING to Consul Halstead, of Birmingham, an estimate by two French experts gives the total annual production of rubber throughout the world as 57,000 tons. Of this total, 55 per cent. came from South America and Africa. The French possessions on the west coast of Africa produce 7000 tons, and the French Kongo 5000 tons, while the output of the Belgian Kongo does not exceed 6000 tons. The consumption of rubber by the principal countries of the world in 1904 was as follows:—The United States, 26,470 tons; Germany, 12,800 tons; Great Britain, 10,000 tons; France 4130 tons; Austria-Hungary, 1320 tons; Holland, 1218 tons; Belgium, 748 tons, and Italy 588 tons.

Consul-General Seeger at Rio de Janeiro also has reported that the rubber shipments from Brazil for the year 1905 were valued at $64,588,406, the average price per long ton being $2,044 for the 31,600 tons exported. The rubber exports and per ton value have both been steadily advancing since 1902, when they amounted to $34,186,564 and $1,241, respectively.

Westinghouse-Finzi Amalgamation

AN agreement was signed March 1 between the Officine Elettro-Ferroviarie, of Milan — the specialties of which company are the manufacture of engines, rolling stock and electrical machinery—and the Paris Westinghouse Company, who manufacture electric machinery and brakes. In virtue of this agreement, the electrical installations to be put down in Italy will be designed in future by both companies jointly; the single-phase traction installations will be named "Westinghouse-Finzi," and will include the application of both the Westinghouse patents and those taken out by Dr. George Finzi, who was the first in Italy to use single-phase motors in traction work. Dr. George Finzi is at the present time one of the directors of the officine.

The first electric sign is said to be that erected by the Long Island Railroad Company, in 1890, at the junction of Broadway and Fifth Avenue, in New York City, to advertise Manhattan Beach. At about the same time Chicago's first electric sign was used to advertise the "Museum." In 1892, Boston's first electric sign was that of the Columbia Theatre.

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The Electric Smelting of Iron Ores

By AUGUSTE J. ROSSI, E. M.

The experiments in the electric smelting of iron ores conducted by Dr. Paul Héroult, at Sault Ste. Marie, under the auspices of the Canadian Government, seemed to have indicated, from the preliminary reports, that the process is practicable for ores unsuited for blast-furnace smelting, and in localities where fuel is scarce and large water-powers are available. In the United States, large deposits of titaniferous iron ores have been left unworked because they could not be reduced satisfactorily in the blast furnace. Mr. Rossi, however, has conducted a series of tests on the electric smelting of these ores, and from the results obtained there would appear to be no doubt as to the practicability of the electric furnace for this work. The subject is first taken up with regard to iron ores in general, and later with regard to titaniferous ores in particular.—The Editor.

THE electric smelting of titaniferous iron ores for the pig-iron they can yield is so intimately connected with that of any other iron ores free from titanium that all that can be said of one, regarding economy of this mode of smelting as compared to the blast furnace method and many other details, also applies equally well to these special ores.

Before discussing this particular question, it is necessary, then, to recall what has been done in this line of electric smelting of iron ores, the improvements realized, and the latest results obtained. The author has smelted these titaniferous iron ores electrically and made from them about 50 tons of an excellent pig-iron; but this incidentally, so to speak, the pig-iron obtained being a by-product of the manufacture of another used in the making of ferro-titanium alloys.

The latter process, though an electrical one, does not come properly under the head of electric smelting of titaniferous ores, electric smelting, as referring to iron ores,—titaniferous or not—having more the restricted sense of applying to the production of pig-iron or to that of steel made electrically and directly from the ores themselves, or by such mixed processes as those known under the name of "pig and ore" or "pig and scrap" methods. These explanations have appeared to the writer necessary to avoid a confusion frequently made. It may be added here that the pig-iron smelted from titaniferous ores by an electric process does not necessarily contain more than a few hundredths of one per cent., if any, of titanium.

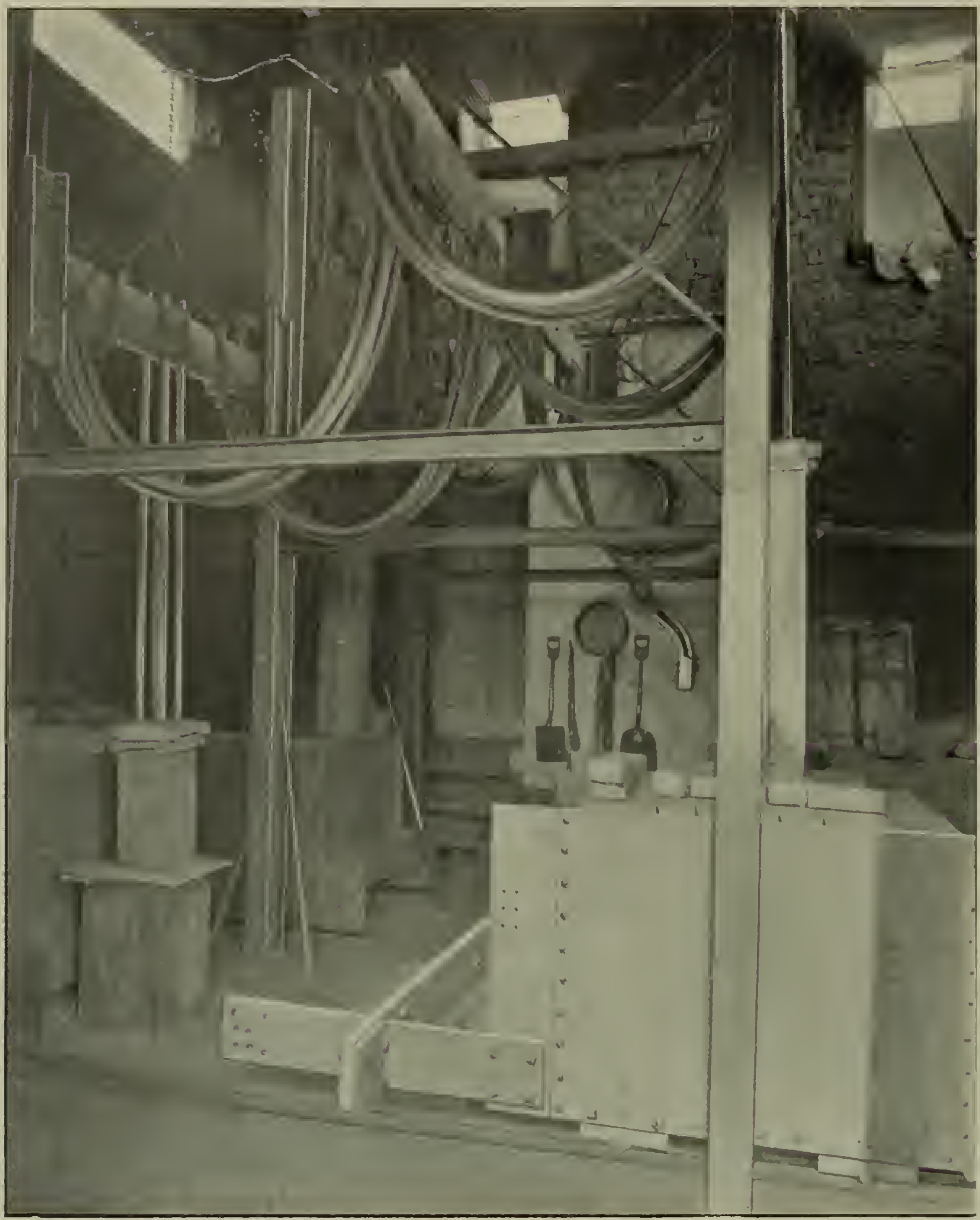
This question of electrical smelting of iron ores is one which the writer had occasion to discuss in its generality about three years ago. It had not been at that time investigated so thoroughly and efficiently as it has been since, not having received the impulse which the work of Keller, Kjellin, Gin, Stassano and Dr. Héroult, amongst others, has given to it by the construction of electric furnaces better adapted for the purpose and improvements in the details of their working.

Such importance has this question acquired as showing possibilities in certain localities where the ordinary method of smelting iron ores appeared inadmissible for divers reasons (thanks to the study made of the method and discussion of its merits by different metallurgists), that in December, 1903, a special commission, composed of competent chemists, metallurgists and mining engineers, was appointed by the Canadian Government to "report on the electro-thermic processes for the smelting of iron ores and the making of pig-iron and steel in operation in Europe." The commission made its report to the Minister of the Interior in Canada on August 1, 1904.

This report has been quoted, more or less, in some technical publications, but too briefly. It has not received all the attention that it deserved, not so much perhaps on account of the actual results obtained as on account of the possibilities of considerable improvements pointed out at the time. Most of them have been realized since with great success. It seems to have been considered more as of a local importance for Canada, while, as we will see, it has really a much more extended scope.

Later on, in 1905, the Canadian Government, encouraged by the results previously obtained, appropriated the sum of $15,000 for tests of the electric smelting of Canadian iron ores. The tests were to be carried on by Dr. Héroult, with improved furnaces constructed according to his plans, under his direction, and in the presence and under the supervision of Dr. Haanel, appointed for the purpose by the Canadian Government.

The furnaces were in operation from February, 1906, to about the middle of March last, with little intermission. During that time about 55 tons of pig-iron were smelted, with an expenditure of 250 H. P. Dr. Haanel has given a synopsis of the results obtained, anticipating the full and detailed report he is soon to publish. The question may then well be called one of actuality, and it is interesting to follow the rapid



ELECTRIC FURNACE USED BY THE AUTHOR IN THE SMELTING OF TITANIFEROUS ORE

progresses made within the last three years or so.

This is germane to our subject, since any advance made in the smelting of iron ores in general applies, of course, to that of any particular iron ores, such as the titaniferous. Under the conditions of furnaces with which the writer worked as early as 1900 and subsequent years, and which were not well adapted to this special smelting, the pig-iron being, as already said, a by-product of other manufacture, the results were not as favourable as those secured by Dr. Héroult lately; but, such as they were, they allowed the writer to draw certain reserved conclusions and to foresee what has been confirmed since as to possibilities of economy, without, however, changing his opinion on the limitation of such possibilities as to the amount of production realizable.

This question of electric smelting of iron ores has been the subject of much controversy. We hear, in fact, on one side, of a pessimism not justified by the undeniable facts already acquired, and on another, of an optimism certainly justified by the results obtained in certain localities, but to which it seems too wide a scope has been given and from which a too hasty conclusion has been drawn.

Let us summarize what may be said to be definitely ascertained from the tests thus far made. In the report of the first Canadian Commission in 1904, the metallurgist in charge reaches the following conclusions:—

1. There is no difficulty in the electrical smelting of gray pig-iron suitable in all respects for acid steel manufacture, either by the Bessemer or the open-hearth process.

2. Foundry iron can be obtained readily.

3. The reactions of the electric furnace as regards the reduction of the different elements found usually in pig-iron, such as sulphur, phosphorous, silicon and the impregnation of the pig-metal with these elements and also with carbon, are exactly the same as in the blast furnace.

By properly proportioning the charges and the conditions and intensity of current, any grade of iron can be obtained as in the blast furnace.

In other words, we have with the electric furnace conditions entirely similar to those of the blast furnace, the difference being in the manner in which the heat necessary for the reduction of the oxides is supplied and the consequences of running which it implies. The question thus arises, how economically can such pig-iron be produced electrically per ton? Many writers on the subject have taken into consideration, in making such comparisons, only the cost of the electric power per year, assuming a figure which, some ten years ago or more, might have been called a minimum, but which now is certainly a maximum.

In many localities electric horsepower can be secured at \$10 per year, in others as low as \$8, and could certainly be created locally for local purposes, with no distribution to sundry customers requiring a special switchboard, at a figure even less than \$8,—certainly not above it. A cost of \$12.50 to \$15 a year per electric horse-power may well be considered now as a sort of maximum.

The question thus comes, what electric horse-power is required per ton smelted a day? It is true that, according to the composition of the ores, the percentage of iron they contain, the nature of the gangues and other conditions, important differences on this score may be accounted for, but not to a considerable extent. It should be remarked also that owing to the imperfection in the construction of the furnace for the special purpose of smelting iron ores electrically, the first results obtained were not as favourable as they have been since. In fact, in most of these furnaces, their construction implied a great waste of utilizable heat energy.

In the blast furnace, carbon burns first to monoxide, CO, and then in part to CO_2, but while 1 kilogram of carbon burning to CO disengages 2473 calories, 1 kilogram of CO_2 disengages 8040 calories, each kilogram of such CO burning to CO_2 and generating additional calories. Owing to the small height, in general, of the column of charges in the first

tests, the carbon monoxide burnt to CO_2 at the very top of the furnace as it escaped, and then without any useful results, the heat of the gases not even being utilized, in most cases, to preheat the charges before their introduction in the furnace.

Without entering into the details of the operations carried on before the Canadian Commission in 1904, it may be said that as a result of careful measurement of the current supplied, pig-iron smelted, materials charged and actually used, there were found required the following amounts of power per ton- (2000 pounds) year:—0.47 E. H. P.-year; 0.475 E. H. P.-year; 0.350 E. H. P.-year as an average of two runs.

These figures correspond per day to 170.55 H. P. per ton of iron; 172.37 H. P., 127.75 H. P., or say, 172 H. P. to 128 H. P.; but in order to compare results as to economy of the two methods of smelting, we must take into consideration that in the blast furnace process the ton is reckoned as 2240 pounds and not 2000 pounds, which gives us, per ton of 2240 pounds or gross ton per day, 192 H. P.-day to 143 H. P.-day (special run). Assuming, as the Canadian report does, the cost of the electric horse-power-year as $10, or 2¾ cents per day, we get for the cost of energy per gross ton-day, $5.25 to $3.93.

From these figures the report concludes that, taking into consideration the actual cost of the ore (55 per cent. metallic iron) at $1.50, the wearing of the electrodes, the labour at $1.50 per day, repairs, general expense, amortization, coke used,—0.34 ton at $7 per ton,—the cost of pig-iron could be established at $12.05 per gross ton. But $7 per ton for coke is obviously too large. If we reduce it to $4 and deduct the difference it makes, we come to $11.03 as cost per gross ton in the electric furnace.

A calculation made by the metallurgist of the Commission estimated the cost of pig-iron in the blast furnace to be $11.34 for the same price of ore ($1.50) and coke ($7); assuming only from $2.50 to $2.75 as the price of coke at the blast furnace and $4 to $4.25 for the ore (11.842 tons of ore were used in the tests), we get $11.50 to $11.75 as the cost at the blast furnace based on the same data, excepting the price of coke and ore, or say, practically the same cost by the electric smelting as by the blast-furnace method, for coke delivered at $4 at the electric furnace, and at $2.50 at the blast furnace, and ore at $1.50 at the latter and $4 to $4.28 at the former.

These figures are given without comment just as they appear in the report mentioned.

All the later modifications of the electric furnace have been made for the purpose of utilizing to the utmost the available heat now wasted, and this desideratum was so far realized by Dr. Héroult in the tests made in Canada that we are told that the electrical average per ton of 2000 pounds per day was reduced to 83.50 H. P., corresponding for a gross ton of 2240 pounds to 93½ cents, and that still more favourable results could be expected.

No official figures have been given yet by Dr. Haanel, but Dr. Héroult has made an estimate based on results obtained so far; it is stated by Dr. Héroult that results better still than 1000 H. P. per 12 tons of pig-iron-day (2000-pound tons), or 10.75 tons of 2240 pounds, can be expected by the use of his method and furnace, which render possible the transformation of all the carbon monoxide to dioxide inside the furnace, air being blown in at the proper height to this effect, thus utilizing to the utmost all the heat available. No air blast was used during the tests, however, but it is stated that two short experiments made in this direction showed decided improvements, which would seem to justify Dr. Héroult's expectations.

For lack of official figures, it may be premature to discuss this question. All that we can say for the present is that in the description of his patents referring to the improvements in the furnaces and mode of operating, Dr. Héroult seems to have adopted for certain thermic constants, such as number of calories required for the reduction of 1 kilogram of iron, for instance, figures which are somewhat below those generally assumed in such metallurgical calculations.

However this may be, and without contesting the possibilities of a further slight improvement by the methods proposed by Dr. Héroult, it remains as an acquired fact, from figures given so far relating to the tests made at Sault Ste. Marie, that we can, by electric smelting, reduce 1 gross ton of pig-iron at an expenditure of 93½ horse-power and possibly even less.

These results are far better than those recorded by the first Canadian Commission. At $10 per electric horse-power-year, or 2¾ cents per day, 93½ electric horse-power represents an expense for energy per gross ton of $2.75. If coke cost about this price at the blast furnace, and if we assume that all other elements entering into the cost of making iron are the same, so far as cost in both cases is concerned, it is clear that pig-iron could be made electrically at the same price as in a blast furnace, and were the electric horse-power to cost less than $10 a year, there would be an advantage in the matter of economy for the electric smelting process. There may even be found such local conditions as to price of ore mined near the

THE TRANSFORMER ROOM. THE CURRENT IS STEPPED DOWN FROM 2200 VOLTS TO 20, 80 OR 100 VOLTS OR MORE

electric furnace that it would compensate for a higher price of the electric horse-power were it to cost more than $10.

Without entering into details of figures, it appears clear that there may be such a combination of favourable circumstances as cheapness of ore and low cost of electric energy generated for this special purpose which would make the electrical method compete favourably in the matter of economy with the blast-furnace process.

It is, in each case, a question of determining by a simple calculation on which side the balance of economy can be found. We may also add that certain ores, inadmissible in the blast furnace, owing to the presence of sulphur, for instance, which is of no consequence in electric smelting, as Dr. Héroult's experiments are said to have shown, could be used in the electric furnace and secured at a much lower cost,—$1.50 a ton. Dr. Haanel states, indeed, that such ores, high in sulphur and not used in the blast furnace, on account of the high percentage of this element, could be smelted electrically with perfect success, yielding a pig-iron equal in value to and lower in sulphur than the metal obtained in the blast furnaces from ores free from sulphur and costing $3.75 per ton in Canada.

In blast furnaces, the quality of the coke or fuel is a matter of great importance. In an electric furnace, charcoal made of refuse, of the smallest twigs of bark, dust from anthracite, refuse from mines, coke made from peat and lignites, can be used without disadvantages. From 1900 to 1903 the writer has used charcoal and refuse from anthracite at $1.25 per ton of carbon contents in his electrical furnaces at Niagara Falls. Furthermore, the amount of carbon required in an electrical furnace is but a fraction of that required in the blast furnace, the carbon being there merely for the reduction of the anodes, the heat, so far as reduction and smelting products is concerned, being supplied by the current.

We must arrive, then, at the conclusion that whatever may be the nature of the iron ores, let them be titaniferous or not, there are conditions of prices of current and materials, even of composition of certain obnoxious elements and of the physical and the chemical character of the fuel which, as a result of the latest tests made at Sault Ste. Marie, prove the possibility of the real economy of the electric smelting process in many circumstances when moderately favourable as to localities. It may be added that the establishment of an electric plant is much less expensive for moderate production than that of a blast furnace of the same size and that electric smelting adapts itself readily to the law of demand and supply by the opening or shutting of a switch.

But let us assume the best results obtained so far. Let us take the figure of 1000 H. P. for $10\frac{3}{4}$ gross tons per day given by Dr. Héroult, or even 11 tons; in order to produce per day what a single one of our monster blast furnaces do, say, 700 gross tons, we would want, as electrical energy, about 63,600 H. P., an amount not very easily generated in one place, and certainly difficult, to say the least, to duplicate, if at all, in any one place.

Statistics show that of last year's total production of pig-iron, about 10,500,000 tons, in round numbers, were smelted in the Pittsburg district alone; this corresponds to 28,767 gross tons per day, and would suppose the generation of electric energy of from 2,615,000 to 2,670,000 H. P. to produce these 28,767 ton-days, at the rate of 10.75 to 11 gross tons per 1000 H. P.

It is safe to say that, with allowance for transmission losses, 3,000,000 H. P. would be a more exact figure; but the ores necessary for such a production concentrated in the Pittsburg district have to be brought from far away at a cost not less than about $4 per ton at the furnace, and with these conditions, no electric furnace could compete with the blast furnace, even assuming that it would be possible to generate such an enormous power in the limited district and to supply it at $10 per electric horse-power per year, or even somewhat less.

In other words, electric smelting has a limitation, so far as the concentration of the same industry in a given district and the amount of production are concerned. It may, on the other hand, have the tendency to decentralize an iron industry with all the advantages, but also disadvantages, it implies, by securing in different places the conditions of low price of ores and current and the possibility of using inferior fuels inadmissible in the blast furnace.

This is true, for instance, for the Pacific coast. The writer was recently consulted on this subject of electric smelting in the San Francisco district. It was represented that excellent magnetite with 90 per cent. of oxide of iron could be delivered at a furnace at $1.50 per ton; limestone was available at 75 cents per ton, coke at $2 to $2.50, and an electric horse-power at $12.50, or at most $15. Under these conditions, with a freight from the East of from $8 to $10 per ton, electric smelting would be particularly well adapted for local wants.

An important item of the cost in electric smelting is the wearing of electrodes. The writer's own practice has shown that 50 to 80 cents per gross ton were a fair allowance; the Commission's report gives 77 cents per ton, and Dr. Héroult points out a further reduction to 35 cents per ton (gross ton). Without assuming an optimism not justifiable in many cases, we may conclude, however, from the latest results obtained and with such ores as it is hoped may be secured, that electric smelting of iron ores has passed the experimental stage and has been brought down to a sufficiently practical economy as to cost of current per gross ton smelted, expenses of electrodes, and others incident to the process, to justify the statement that if it cannot also compete with the blast furnace so far as the enormous production per day of the latter is concerned, it can, however, certainly maintain its own in economy of production in favourable conditions of locality as to price of ores and current, and secure there a local production for local wants.

But if this is true for iron ores in general, it is certainly true as relates to a certain class of ores, the titaniferous iron ores. These, for some reason which we will not discuss here,—prejudice, routine, unreliable and contradictory statements, falsely interpreted results, possibly also lack of knowledge some years ago of the properties of the titanium compounds in general, to the study of which the writer has devoted the last ten years or so,—have not been, so far, smelted in the blast furnace to any important extent.

These ores, the geology of which has been studied by Prof. F. Kemp, of Columbia University, occur in the United States in "immense deposits," "in mountain masses" in the Adirondack region. They are "one of the most marvellous deposits of the United States." They are found almost as abundantly in Minnesota, Michigan, Colorado, North Carolina, and most everywhere in the United States, and also in Canada, Sweden, Norway, New Zealand, Russia and other countries. In many districts, such as the Adirondacks, for instance, they could be mined for years in open quarry, constituting, as they do, the geological formation itself.

They are very rich in iron, containing 57 to 60 per cent. of metallic

iron, are low in sulphur (0.025) and phosphorus (0.017), and also in silica ($1\frac{1}{2}$ to 2 per cent.), with about 15 per cent. of titanic acid. Occurring in an igneous formation implies their being found in mountainous districts that are precisely in regions where it is possible to generate electric power for smelting purposes at a minimum cost. Lakes of 3 and 4 miles in length by $1\frac{1}{2}$ to 2 miles wide, with falls of about 60 feet from one to the other, are found, for instance, with a number of others of lesser dimensions, in the districts from which the writer has drawn much of the ores used in the manufacture of alloys. Charcoal can be had at a very low cost, limestone or other suitable fluxes are within easy reach, and the product, pig-iron, could follow a down grade to the tide water.

The writer has quoted this region with some details merely on account of its being familiar to him. But in many places in Canada and elsewhere similar ores occur also in abundance, being even available by means of water or other communication, and there, as in the Adirondacks, could be created locally an iron smelting industry with conditions of economy particularly favourable. It may be added that even for about twenty years these ores have been successfully smelted in the Adirondacks in blast furnaces, one of them of a capacity of about 14 to 15 tons daily, as early as the "forties," from 1840 to 1859, or thereabouts. Lack of direct railroad communications stopped this industry.

The writer has smelted ores of this class in a small blast furnace constructed by him in Buffalo, as a demonstration of the possibilities of such smelting, and has smelted them also in the electric furnace. Were the pig-iron they yield of ordinary quality, the importance of these deposits would be sufficient to call attention to them. But what do we find in the literature on the subject, even from those the most ready to consider their smelting in a blast furnace as at least difficult or certainly uneconomical if realized?

"The quality of pig-iron smelted from titaniferous iron ores is exceptionally good." "These ores are, as a rule, generally free from phosphorus and also frequently from sulphur." "Though the titanium, not being reduced at the temperature of the blast furnace to any extent by carbon, is found, if at all, only in very small percentages (a few hundredths of 1 per cent. or a few tenths at most) in the pig-metal, the strength of the pig-iron is thereby increased." The pig-iron smelted from these ores is "a wonderful metal"; "a splendid metal"; "all that can be desired." "It is eminently a stock well suited for the open-hearth acid or basic processes."

We could multiply such quotations and bring a number of testimonials of the same character, but we will limit ourselves to one which speaks for itself. The pig-iron made from these ores in the Adirondacks as well as the iron puddled from it and steel made by cementation was awarded in 1851, at the World's Fair in London, a prize medal for excellency. This medal is in the writer's possession.

About 100 tons of such pig-iron was smelted by the writer in 1895 in a small blast furnace in Buffalo. It had all the qualities mentioned above and was eminently adapted for car wheels, chilled rolls and crushers. Used for car wheels, according to the statement made by the president of a car wheel company, "it gave greater density to the metal, increased the transverse strength and gave a harder chill and wearing quality to the wheel, hardening the tread and strengthening all parts of the wheel, including the plates." All the above was quoted as being germane to our subject. Indeed, if for some reasons of economy or others justified or not, and which it is not intended to discuss in this article, these titaniferous iron ores are not smelted in blast furnaces, and consequently not worked for such purposes, they belong to the class of ores for which electric smelting would be well indicated.

In the electric furnace no question of economy of fuel can be argued against them, no question of the greater or lesser fusibility of a slag containing titaniferous acid can be brought out as a drawback, no question even of difficulty of reduction under the conditions in which they would be smelted and under which the writer has smelted them electrically. No titanic acid is reduced practically or intended to be, consequently the only oxide reduced from them is the oxide of iron, and let it be in a titaniferous or non-titaniferous ore, this oxide (ferrous, ferric or magnetic oxide) cannot require more heat, more calories per kilogram of each individual kind, per kilogram of iron reduced by one process than by the other.

We have thus in these ores a material capable of being reduced in as favourable conditions as any other ore under the same economical conditions, in fact, as we have found it to be established by Dr. Héroult in his recent tests and stated by Dr. Haanel to be possible. If thus it is considered economical under favourable local circumstances to smelt ordinary iron ores electrically, and as these titaniferous ores generally occur precisely where these favourable circumstances are most likely to exist, ores now not used for blast-furnace smelting would find in this electric method an opening denied to them, for the present at least, in the blast furnace, for whatever reasons, justified or not, this may be.

We may add that, if the pig-iron smelted from these ores, though containing a very small percentage of titanium, if any at all, a few hundredths or tenths of 1 per cent. at most, has the qualities claimed for it, and recognized, to judge from the above quotations, it may well command a higher price on the market for many special applications. Indeed, the pig-iron smelted electrically by the writer was not so done as a distinct industry, and though about 50 tons were made it was merely as a by-product of another manufacture.

In making ferro-titanium of different percentages of titanium with ores from the Adirondacks and Canada, the writer has manufactured alloys containing carbon and others practically free from it. For the latter class of products a special method, consisting of a bath of aluminum as reducer of the oxides of the ore, was used. In case alloys were required higher in titanium than those which a given ore or mixture of ores could yield, owing to the relative percentage of titanium and iron it contains, "Rutite" was added to the charges. This is a mineral containing from 75 to 95 per cent. or more of titanic acid, and though obtainable now at one-third to one-quarter of what it cost a few years ago and admissible on this score, commands still a high price.

Furthermore, there is an advantage, when making ferro-titanium with aluminum as a reducer, to use titanic acid in some form and to a certain extent, instead of titaniferous ores alone in the charges, as the reduction of the ores for their titanium contents implies forcibly the reduction, at the same time, of the iron ore they contain and the consequent addition of a certain quantity of aluminum for this purpose.

In order to avoid the expense thus incurred, the following method has been resorted to in order to secure what we may call an artificial Rutite or concentrate of titanium oxide, TiO_2:—

These titaniferous ores are smelted electrically only for the iron they contain, by adding just enough carbon in some form for the reduction of the oxides of iron, but not that of titanic acid, and operating with conditions of intensity of current much less than was required when making ferro-titanium alloys, by the complete reduction by carbon of all the oxides they contained (oxide of iron, oxides of titanium).

By operating in this manner, there has been obtained an electrically smelted pig-iron containing but 0.03 to 0.05 per cent. or less of titanium and a slag, an igneous concentrate of titanic acid, containing practically all the titanic acid of the ores charged, combined with the earthy bases,—lime, alumina, and magnesia, —of the gangue of the ores, and such lime as might have been added as flux, and only a small percentage of oxide of iron,—1 to 3 per cent., more or less,—as is found in slags obtained in the blast furnace from the smelting of iron ores free from titanium.

The following data of some of the runs may prove interesting as illustrating the method:—

Ore Used, Adirondacks	
Silica	1.50
Magnetic oxide of iron	80.00
Titanic acid	16.50
Earthy bases	2.25
	100.25

Pig Iron Obtained	
Sulphur	0.023
Phosphorus	0.037
Silican	0.13 to 0.20
Titanium	0.02 to 0.05
Carbon	2.75 to 3.00

Slag Concentrate		
Silica	3.00	3.60
Titanic acid	66.75	70.80
Bases	9.00	10.05
Lime	19.30	14.02
Iron oxide	2.25	1.90
	100.30	100.37

As to the fusibility of a titanic compound of such composition as the above slag, the writer's work on the properties of the titanium compounds, titanates, silico-titanates, has shown as the results of numerous experiments that it will practically melt at the same temperature as that of fusion of such silica slag, for instance, as accompanies gray iron in a blast furnace. Notwithstanding the printed opinion of some writers that titanic acid, even in very small quantity, is a cause of infusibility in a compound, we find in a paper read before the American Institute of Mining Engineers in 1904, on the refractory properties of American fire clays, the following:—"Titanic acid is now placed amongst the fluxes, since recent investigation has shown that even 2 or 3 per cent. of this acid added to a high-grade kaolin will lower its point of fusion two or three (Sieger) cones numbers."

If thus, the fusibility of the slag does not require any more heat practically than for any other ore not containing titanic acid, but silica to the same extent, there cannot be any reason why the electric smelting of titaniferous iron ore should require any more electrical energy than is found necessary to smelt other ores free from it under the same economical conditions, owing to disposition of furnaces and method, as were met with in Dr. Héroult's latest experiments.

Thus, for such smelting of titaniferous ores we can assume per gross ton of pig-iron about 95 H. P. per day, which at 2.75 cents per day ($10 a year) represents $2.61 as an item of cost on the score of electrical energy. These Adirondack ores, from a report made by a mining engineer of high repute, could be mined at 25 to 30 cents a ton in open quarry, and could be delivered at an electric furnace on the spot, royalty included, at about 70 to 75 cents per ton, or delivered on cars at that price, and the electric horse-power could be secured at less or no more than $10 a year.

Under these conditions, taking into consideration the amount of such concentrates as can be given by 100 pounds of the ore mentioned above, and their percentage in titanic acid, it can be calculated that, bsides the pig-iron obtained as a by-product, the titanic acid would cost only about 30 to 35 cents a ton, or much less, if made from ores like those in Canada, containing much less iron,—35 to 36 per cent.,—and as much as 38 to 39 per cent. only of titanic acid, with about 10 per cent. of gangue. This is for ores which could give, per 100 pounds, about 50 to 55 pounds of such concentrates and which contain also about 70 per cent. of titanic acid for every 38 to 39 pounds of pig-iron obtained.

In short, by smelting these titaniferous iron ores for pig-iron, it is possible to obtain a material rich in titanic acid which can serve as a first material for the manufacture of alloys of titanium of any percentage of titanium desired, containing or free from carbon.

The furnaces used by the writer for such electric smelting were not intended, as has been said, for this specific purpose of smelting iron ores and, as such, were not constructed to utilize to the full extent or even to any important amount, the available heat contained in the gases, which escaped at the top of the furnace and burnt there without any utilization of their heat other than, in some of the tests, to preheat the charges to some extent.

Without entering into the details of its construction, it may be said that the furnace was of the old Siemens arc type, and consisted of a masonry of graphitic materials provided with a central cavity forming a crucible in which could be lowered the carbon electrode. The iron shell in which the furnace was enclosed was connected with the bus-bars, and, with the graphitic material, formed the anode. The carbon cathode was connected by means of copper rods with a copper cross-bar, which moved vertically between two upright posts. Raising and lowering was done by means of a rope and windlass.

The current passed through the charge, which consisted of a mixture of titaniferous ores and charcoal or carbon in some form. The charge was put in between the electrode and the sides of the cavity. When alloys free from carbon were made, the central cavity was lined on the side with magnesia brick. The furnace was closed in at the top by means of bricks or broken electrodes, or sometimes kept open, or again charges were piled around the electrodes at the top, thus, to a certain extent, realizing a utilization of the sensible heat of the gases as they escaped at the top and were transformed into carbonic dioxide outside of the furnace.

Results were obtained which entirely confirm the possibilities of economy of smelting, which the latest tests of Dr. Héroult, as reported by Dr. Haanel, have realized. The energy supplied was about 200 H. P. A wattmeter recorded at the furnace 173 to 175 electric horsepower, and with this, under the most unfavourable circumstances, about one gross ton of pig-iron could be made in twenty-four hours. By taking into consideration differences of compositions of ores, bad insulation, loss of current or heat, we may estimate a maximum based on this figure at the time, 1903, of about 180 to 200 H. P. per gross ton, as likely to be the worst figure for comparison with blast furnace smelting. As it will be noticed, it is very close to the figures recorded by the first Canadian Commission, the furnaces operating also in similar unfavourable conditions as to economy of power.

A few tests made incidentally with the furnace closed at the top with material piled around the electrodes to be preheated before entering in the furnace proper to be reduced, gave such a favourable figure as 135 to 145 H. P. per gross ton. This demonstrated in what line the apparatus could be improved for a manufacture specially intended for

pig-iron as the sole product and with a furnace properly constructed so as to utilize to the utmost all the possible heat available in the process.

When making alloys free from carbon by the aluminium bath method, the aluminium was melted first by the current and in the molten and melting mass was shovelled the coarsely powdered charge, consisting of titaniferous ores alone or mixed with "Rutite" or concentrate. In this case, of course, there being no carbon present, no utilization of the gases was admissible, there being lost merely the sensible heat of the escaping volatilized products, such as alumina, the result of the reaction of aluminium on the metallic oxides; but this has nothing to do with the electric smelting of iron proper, and we mention it only in passing.

If, when in making pig-iron from these titaniferous ores, a current of higher intensity was used and carbon was added in the charges in such proportions as to reduce only a part of the titanic acid of the ores, a pig-iron was obtained, a "titanic pig," as the author has called it, containing a certain definite percentage of titanium. It is a "pig-iron," distinct from ferro-titanium, in that while, with a limitation of the percentage of titanium, it melts at the temperature of fusion of cast iron, the alloys above this percentage do not, though dissolving readily in it.

It is such a pig-iron that the writer has also manufactured electrically by the ton. It contains about 3½ to 4 per cent. of titanium. Not only is it a remarkably strong metal by itself, but it can be used directly in the cupola in foundries in mixture with other pigs like any other pig-iron free from titanium. The writer has used it in cupola mixtures just as his higher alloys could be and were added, but in smaller proportions.

The addition of this "titanic pig" imparts very valuable qualities to the metal treated, such as soundness of castings which are free from blow-holes, of a close texture and well adapted for all purposes of foundry where strength is required. If the castings made from such mixtures be chilled, they are both strong and hard with a deeper chill in the parts which require it.

The manufacture of this pig-iron comes, then, under the designation of electrical smelting of ores, as it can be obtained only at the heat secured by an electric current, titanium, as we have already said, not being reduced by carbon at the temperature prevailing in the blast furnace or even the open hearth. This pig-iron, owing to its qualities for mixture, can command a higher price, just as charcoal Scotch pig commands a price which pays for the extra amount of energy required, which is not much more than 15 per cent. above that necessary to smelt electrically, ordinary pig-iron free from titanium. Such "titanic pig" could be made by the ton at a cost of about $3.88 per ton-day for electrical energy, the electric horse-power-year being counted at $10 a year.

Practice has shown that 1 per cent. of a ferro-titanium alloy with 10 to 12 per cent. of titanium or its equivalent, about 3 pounds of titanic pig with 3½ to 4 per cent. of titanium or even less, is sufficient to secure in cast iron the beneficial results mentioned above,—freedom from blow-holes, soundness of castings, and consequent strength. It naturally suggests the question, how does the titanium act to secure such results if only a few hundredths of 1 per cent. of titanium at most are found in the metal treated, as is the case with pig-iron smelted in the blast furnace from titaniferous ores?

Papers read at the Liege Congress of Metallurgy last year by eminent European metallurgists, and experiments carried on by the writer and others here and abroad, show that its action is to remove the occluded gases, such as oxygen and especially nitrogen, of which the deleterious influence has been compared to that of phosphorus in steel. "Nitrogen, indeed, combines readily with titanium, forming a stable nitride which prevents the formation of blow-holes and thereby produces solid ingots and castings." As Dr. R. Moldenke said, "the titanium reacts directly with any oxygen or nitrogen present in solution, and as a consequence a purification takes place which cannot be overvalued, and the strength of the iron is increased 20 per cent."

We have thus in the electric smelting of titaniferous iron ores under certain conditions, the possibilities of producing a special pig-iron, a "titanic pig," of great value in itself for treating other pig-irons, and which can only be obtained, as has been explained, by an electric process, without mentioning the use of higher alloys in smaller quantities for the same purpose.

But there is a source of heat for electric smelting which has more recently attracted a great deal of attention and of which it may be interesting to say a few words as germane to our subject. In the blast furnace the gases escaping at the top are used first to heat the air blown in the furnace, and, second, to generate steam under boilers for all the power required in the plant, blowing engines, hoists, crushers, and the like. These gases contain about half of all the heat available in the coke consumed per ton of iron. Allowing such percentage of this half as is necessary to heat the blast, it has been shown that of the balance supplied to the boilers not 5 per cent. are really and profitably utilized.

Gas engines, within the last ten years or so, have reached such a development that a utilization of 25 per cent. of the calorific value of these gases can be secured. It has been calculated that if this part of the heat contained in the waste gases of a blast furnace which is not required for heating the blast was transformed into power by means of gas engines, after making due allowances for the amount of these gases necessary to supply by means of gas engines the mechanical power required by the plant, there would be a surplus available capable of generating energy to the amount of 550 to 850 horse-power per ton of pig-iron made per hour.

For an estimated production in 1906 of fully 20,000,000 or probably 23,000,000 tons of pig-iron, or 2240 tons per hour, this would amount as available power, for other purposes than those of the blast furnace plant, to 1,200,000 or 1,900,000 horse-power-hours, according to the amount of gases per ton of iron smelted, the amount depending to quite an extent at least on the weight of coke consumed per ton of iron.

This opens up possibilities of electric smelting for steel manufacture, for instance, not considered before, as an electric horse-power could be created near a blast furnace independently of any natural sources of power. It has been established already as a result of the tests made by the first Canadian Commission in 1904, that steel in all respects equal to the best crucible steel of Sheffield can be produced by any of the methods proposed and examined by the Commission at a cost considerably less than the cost of production of a high-class crucible steel. Special steel can thus be manufactured with great advantage, and certainly we may add any of the ferro alloys used in the manufacture of steel under favourable conditions as to price of current.

In the same way this surplus power could be used to smelt these titaniferous iron ores, producing a valuable metal or a special pig-iron, such as "titanic pig," for applications

in foundry practice simultaneously with or independently of the higher ferro-titanium alloys.

We may add that as this "titanic pig," with $3\frac{1}{2}$ to 4 per cent. titanium, does contain but a part, and with certain ores but a small part, of the titanic acid found in them, the slag resulting would prove a valuable source of titanic acid for other purposes, unless, as the writer has practiced it in smelting this "titanic pig" electrically, to the ores themselves were added, in the charges, scrap iron or pig-iron in sufficient quantity to reduce in the increased product obtained the titanium contained in the charges to about 4 per cent. of the total "titanic pig" smelted. We might add that for making steel electrically the electric horse-power required is only one-third or less of that required for making pig-iron.

All that has been said above of the relative economy of electric and blast furnace smelting is based on the results of the latest tests made at Sault Ste. Marie as given so far,—that is, about 93 H. P. per gross ton of pig-iron a day, a figure which, it is claimed, could even be bettered. This may be so or not, and even the first one of 93 H. P., or thereabouts, may not be reached in all cases with all kinds of ore in all circumstances; but even were it increased 10 per cent. or even 20 per cent., that is, to about 100 or 110 H. P. for possible contingencies, it is low enough to see that there could be many cases still in which cheapness of ore, fuel, current, and other conditions would throw the balance of economy on the side of electric smelting.

This would be certainly true for the special pigs we have spoken of, such as the "pig-iron" or the "titanic pig" smelted from titaniferous iron ores. But it would still more emphasize what has been said about the limitations of the electric smelting as to amount of production possible in a given district.

If for a given ore we take into consideration such figures as are generally adopted for thermic constants and calculate the number of calories required to reduce the iron of the ores, melt the pig-iron obtained, impregnate it with silicon, carbon, and other elements found in it as a rule, melt it and melt the slag resulting from the addition of proper fluxes, taking also into consideration the heat to be supplied to raise the charge to the temperature of the reactions, but giving to the furnace the credit of the heat supplied by the combustion of the carbon to CO, it is possible to show that the combustion of this CO to CO_2 could supply an amount of heat or its equivalent in electrical energy equal to about 50 per cent., more or less, of the electrical horse-power required as calculated above. Even with the furnace used in the tests in 1903, the heat of the combustion of carbon to CO was certainly made available to an important extent and should be deducted from the necessary heat required to be supplied by the current.

We could then legitimately hope to reduce the electrical horse-power required per gross ton to about half with such improvements fully realized, and, indeed, if we take one-half of the figures recorded in the Commission's report of 1903, that is, half of 192 H. P. per gross tons, we get 96 H. P., which is practically the figure obtained by Dr. Héroult and stated by him to be that resulting from the data of the tests of 1906, namely, 93.5 H. P. per gross ton.

We may add in closing that electrically smelted pig-iron, being obtained, as a rule, at a higher temperature than in the blast furnace, is more fluid and thus more free from blowholes, of a closer texture resembling that of steel, and, as such, is a superior product to the metal smelted in blast furnaces.

The Development of the Nickel Plating Industry

By ISAAC ADAMS

From a Paper Read at the Ninth General Meeting of the American Electrochemical Society

FIFTY years ago, a little more or a little less is immaterial, the state of the art as regards electro-deposition of metals was about as follows:—Copper was deposited from the acid sulphate, with a near approach to theoretical efficiency. Silver and gold were extensively deposited from extremely alkaline solutions with nearly theoretical efficiency. Brass, iron and platinum were also used as covering metals, but only to a trifling extent in comparison with the others.

In those days, intelligent workers in the field of electrochemistry were few and far between. The published works of Smee and Gore in England, Roseleur in France, Elsner in Germany, and a few others whose names the writer cannot recall, represented all that was known of the practical or industrial art of electrochemistry. Compared with what there is known to-day, one might say that the art did not exist at all. Notwithstanding the great advances, both in theory and practice, in one respect, however, there has been no change.

In the chase after solutions from which metals could be practically deposited, the rule of thumb method prevailed, and had to prevail. Take, as an example, the search for a practical silver-plating solution. Doubtless, hundreds of silver salts were tried before the rather out-of-the-way double cyanide of silver and potassium were found. In the case of untried metals, the experimenter could not safely draw any inferences from similar combinations. There were no rules and fewer theories to guide. It was a matter of the "cut and try" method of the machinist of that time, and it is much the same to-day.

The first commercial nickel plating, so far as the writer is aware, was carried on in a small room on Fourth street, Boston. The immediate occasion was this:—During the years 1858 and 1859, the writer had been investigating the electrolytic possibilities of many nickel and cobalt salts, and had become familiar with the properties of these metals, both in the pure, fused condition and in the form of electrotypes. The latter were small sheets of from three thousandths to five thousandths of an inch in thickness, stripped from polished sheets of brass used as cathodes, of about 3 by 4 inches in dimension.

Precisely how the thing came about, the writer cannot at this distance of time recollect. It will suffice to say, however, that the writer somehow managed to interest a Mr. Joseph Smith, of Boston, a dealer in gas fixtures, to start the business of nickel-plating cast-iron gas tips, he to furnish the capital and the writer to do the plating. So it happened that along in the winter of 1865-66 operations were commenced with about 20 gallons of solution and with cast-nickel anodes.

The writer took out a patent at the time (the first nickel-plating patent on record) for a nickel-plated gas tip as a new article of manufacture. More than 100 gross of these iron tips must have been plated, besides a good many brass ones.

The tip was good enough, but more money could be made on the lava tip, which was then beginning to be ex-

tensively used, and which, in fact, soon after practically drove all other tips out of the market.

The next attempt to place nickel-plated goods upon the market was made in the winter of 1868-69 by Wm. H. Remington, under the firm name of Wm. H. Remington & Co.; the company, in this case, being a lady well-known in Spiritualistic circles, and herself claiming to be a medium.

Mr. Remington, who had had some experience in electrotyping, represented in the firm the "skilled-in-the-art" man, while the rôle of the lady partner was, in some mysterious way, to control all baneful spirit influences and, if possible, to filch from some unsuspicious spirit bits of information and knowledge which might be of use to the firm and which could be obtained in no other way. (Whatever has been said or may be said as to spirit influences in nickel plating, is given in part from the writer's personal knowledge, but mostly from testimony given in the case of "United Nickel Co. vs. Anthes," United States Circuit Court Records.)

Mr. Remington had produced in his laboratory samples of nickel plating on articles which could easily be carried about and exhibited, such as teaspoons and harness hardware, and these, so far as outward appearances went, were very well done. Early in the winter of 1868-69, Mr. Remington, having previously obtained a backer with the necessary capital, started in to do nickel plating for the public. His principal contribution to the business was a grain-nickel anode, which he patented, the excuse for making and using such an anode being that the metal could not be melted and cast. (Strange as it may appear now, the idea that nickel could not be commercially melted and cast was prevalent among both the users and the manufacturers of that day.)

Mr. Remington's shop was located in Province street, Boston, Mass., and was well stocked with the solutions and tools necessary to the business. There were several plating tanks holding, in the aggregate, from 400 to 500 gallons of nickel solution, a hot caustic soda bath and a hot cyanide of copper bath. The electrolyte was originally a solution of nickel chloride, with an excess of ammonium chloride; the number of employees was from 15 to 20, mostly brass finishers.

Mr. Remington used a current of very high voltage, and had to, for lacking that, no nickel was deposited, and if an attempt was made to thicken the deposit, the metal riffled up into minute brownish spangles, a totally useless covering. Twenty-four Grove cells in series were attached to one tank. Whether the baneful spirits got in their work here is not known, but Mr. Remington's efforts ended in utter failure. His financial backer, becoming frightened about this time by the continued demands made on him, employed Moses G. Farmer, an old-time electrician and the father of the fire alarm system, to investigate matters.

To make a long story short, the writer was called in to straighten matters out. Mr. Remington, in the attempt to render his solutions more efficient, used numerous "dopes," mostly of vegetable origin, and with spirit advice. The last "dope" tried was an aqueous infusion of skunk cabbage. The Province street shop was reorganized and called the Boston Nickel Plating Company, and under that name it exists to-day.

About May, 1869, the writer was advised to take out patents for his process of nickel plating, including the cast anode. This cast anode was certainly "new" and surely "useful," but its validity was never passed upon by the courts. E. A. Quintard, of New York City; A. Gaiffe, of Paris, France, and a Mr. Sellers, of Sheffield, England, soon after became part owners of the patents. Simultaneously with the restocking of the Boston shop with solutions and anodes, another shop of much larger capacity was planned and opened in New York City. This latter was situated not far from City Hall Square, on Crosby street.

With the facilities then had for manufacturing nickel anodes and salts, matters went rather slowly; but by the end of July, 1869, both shops were in good running order and with plenty of work. The New York shop was in charge of Luther L. Smith, a very capable man, who introduced two new things—a department for grinding and finishing brass and steel articles from the rough, and also a Wilde dynamo, the first successful dynamo for plating purposes used in this country. This shop was afterwards known as the New York Nickel Plating Company, and is still in existence.

Late in September, 1870, Mr. Quintard and the writer visited England, France and Germany, with the view of establishing the nickel plating industry in Europe. A small experimental shop was located soon after in Liverpool, but by springtime we had a fully equipped plating establishment of about 600 gallons capacity in Birmingham.

A shop under the management of A. Gaiffe, a well-known manufacturer of scientific instruments in Paris, France, was opened for business in December, 1869. It was located in Paris, in Rue St. Andreé des Arts, and had a capacity similar to the one in Birmingham.

It is almost needless to say that there was no competition in the nickel plating business at this time, either in this country or abroad, since outside of the shops mentioned, nickel plating did not exist. The competition, and plenty of it, came later on.

By reason of the fine colour and enduring qualities of the covering metal, nickel plating came at once into favour with the public; besides, it was cheap and could readily be used to cover the coarser and heavier articles of commerce, which it served both to beautify and protect. In this country, the industry advanced rapidly, and nickel plating was applied to almost everything under the sun, from watch movements to calender rolls weighing half a ton or more.

In England, owing to the ultra conservatism of the British manufacturer of that date, the advance was much slower. The Elkingtons, however, at that time the largest silver plating establishment in the world, helped not a little by sending goods to which they thought the "new plating," as they termed it, could be usefully applied. They certainly helped largely to keep the pot boiling in the early stages of our struggle with the British citizen.

In France no difficulty was had whatever. Although nickel plating did not jump into prominence as rapidly as it did in this country, still the Paris shop was on a paying basis practically from the time it was opened for business.

Through the good offices of President Dumas, samples of electrotypes and plated articles were brought to the notice of the Academy of Sciences; and, in his presentation speech, he took occasion to compliment the discoverers and to welcome the advent of the "new industry."

This narrative now brings us down to the commencement of the Franco-Prussian War. The art is to-day carried on substantially as it was in 1869-70, with the same solutions, the same anodes, and the same details of shop manipulation.

In accordance with a provision of the New York City charter, the municipal authorities have arranged with the electrical laboratory of Columbia University to test and report on electric meters, about which complaints have been made by users of electric light.

Discrimination in Rates

By J. S. CODMAN

A Paper Read at a Recent Meeting of the Association of Electric Lighting Engineers of New England

THE idea appears to be prevalent among those who are not familiar with the conditions under which electricity is produced, as evidenced by some of the bills recently introduced into the Massachusetts Legislature, that any other charge for electric current than a uniform meter rate of so much per kilowatt-hour is discrimination.

It is often stated that municipalities have no right to charge on any other basis, and that private companies which do so, lay themselves open to criticism from the public. The writer has even occasionally found central station men who subscribe to this idea, and if in practice they deviate from a uniform rate per kilowatt-hour, feel that they are able to do so only because public opinion has not been sufficiently aroused to the injustice of it.

In spite, however, of the public's attitude, electric lighting companies are steadily adopting systems of rates under which the rate per kilowatt-hour is different to different customers, and it is time now that the public should be made to appreciate that such systems are not necessarily discriminatory, but, on the contrary, if properly devised, approach ideal conditions of equity far more nearly than a uniform rate per kilowatt-hour, or flat meter rate as it is often called.

The true non-discriminating system of rates is one in which the charge to the customer bears a definite proportion to the cost of supplying him, and it would seem that for a municipality, at least, the only just way to treat the consumers is to adopt whatever practical system of rates will accomplish most nearly this result, unless, perhaps, as a matter of public policy it is thought best to discriminate in favour of those the least able to pay.

A private company, perhaps, is not so clearly bound to adopt a system of rates proportional to cost of supply, but certainly if it does adopt one, it cannot be fairly charged with discrimination. As a matter of fact, private companies in this country have gone much further in the direction of making the rates proportional to the cost than have municipalities, while just the reverse ought to be the case, and no better example of the greater progressiveness of private companies can well be found.

It will not do, however, for either private companies or municipalities to establish a rate for the majority of their customers and then make special discounts or special prices to individuals, even if it does cost less to supply those individuals. Special rates to special customers will always be a source of ill-feeling and dissatisfaction. Instead, a schedule of rates should be devised which will automatically make the rate proportional to the cost as nearly as possible. This schedule should be published and open to general inspection, and, most important of all, the public should be made to understand that under no circumstances will the published rates be deviated from.

Of the various systems of charging for electricity which have thus far been made use of, the first to discuss, although not the first in chronological order, is the flat or uniform meter rate. It has already been stated that by many this is thought to be the only truly just rate. The writer maintains, on the contrary, that of all the systems ever used, the flat meter rate is the worst as regards discrimination, since under it the charge for electricity is farther than with any other system from being proportional to the cost.

This is due to the fact that in the business of electricity production for light and power, those expenses which are proportional to the actual electricity produced form a very small part of the total expenses including, as we should, interest and depreciation. Ordinarily the expenses proportional to output, or running expenses as they are generally called, are not more than 15 to 20 per cent. of the total. Under these circumstances, let us see how a flat meter rate operates.

Suppose a company is charging a flat meter rate of 10 cents a kilowatt-hour, and that for some particular customer this rate bears the proper portion to the cost of supplying him. If now the number of kilowatt-hours consumed by the customer increases, let us say, 10 per cent., the conditions in other respects remaining the same, only the running expenses will be increased 10 per cent.

As these running expenses are only perhaps 20 per cent. of the total expenses, the increase in the total expenses to the company will be only about 2 per cent., that is, only one-fifth of the percentage increase in output, with the result that the profit to the company from that customer at the 10-cent rate will be greatly increased and may become exorbitant. If, on the other hand, the consumption of the customer decreases 10 per cent., the decrease in expense to the company will be about 2 per cent. and the profit at the 10-cent rate will be unduly reduced or may be wiped out altogether.

A far larger part of the expenses of a station, usually from 50 to 60 per cent., is proportional to the maximum demand on the station, that is, to the maximum load which the station is called upon to carry. It is the maximum demand on the station which determines the size of boilers, engines and generators, as well as the copper in the distributing system; and consequently the interest, depreciation, taxes and insurance on the above-mentioned portion of the investment are proportional to the maximum demand, as are also a part of the station wages, part of the repairs and even a small fraction of the coal, water and waste.

If, then, the part of the expenses proportional to maximum demand is so much greater than the part proportional to output, it is clear that a charge to the consumer based on his maximum demand for current will be more nearly proportional to the cost of supplying him than a charge based on his consumption.

This is roughly the idea of the old contract system where a charge is made for each lamp, or its equivalent in other apparatus, actually installed on the premises, but the basis of the charge with the contract system is clearly the customer's maximum possible demand rather than his actual

maximum demand. The rate is, therefore, not so closely proportional to cost as it would be with a system based on actual maximum demand. Nevertheless, there is little doubt that under the contract system the charge to the consumer is more nearly proportional to cost than is the charge under the uniform meter rate system.

The old contract system, however, has, as we all know, one great practical disadvantage. Since there is no charge whatever on consumption, but only on the capacity of the apparatus installed, there is no individual inducement to economize in the use of current. The result is great waste, with higher rates than would be necessary under economical conditions.

Nevertheless, the contract system with the charge based on actual maximum demand instead of on connected load is a good system to adopt in the case of the smaller water-power plants where moderate waste of current is not a serious matter. By its use, the rate is more nearly proportional to cost than with a meter system, and further, the use of a demand indicator or current limiter for determining the demand will create at once to a certain extent a reason for turning off unnecessary lights.

Now, however, both the contract system and the flat meter rate system have, for the majority of cases, outlived their usefulness, since a better system has been devised which, while it prevents waste just as well as the uniform meter rate system, nevertheless makes the rate far more nearly proportional to cost.

The system of charging referred to is that known as the demand system. If the rate systems of the companies given in the list below are examined, it will be found that superficially they differ perhaps widely. They are all, however, making use of the principle of the demand system of charging. The New England companies are grouped by themselves. This list is not comprehensive. On the contrary, the writer has every reason to believe that an investigation would show that it should be many times longer.

NEW ENGLAND

Boston, Brookline, Chester, Haverhill, Malden, New Bedford, and Springfield, Mass.; Bangor, Me.; Manchester and Portsmouth, N. H.; Bennington, Middlebury and Rutland, Vt.; and New Haven, Conn.

OUTSIDE NEW ENGLAND

New York City, Nyack, Saranac Lake, Rome, Rochester, Lockport and Schenectady, N. Y.; Camden, Hoboken, Jersey City, Mt. Holly, Newark, Passaic, Paterson and Trenton, N. J.; Altoona and Bristol, Pa.; Georgetown, S. C.; Anniston, Ala.; Columbus and Savannah, Ga.; Cincinnati, Cleveland, Greenville and Youngstown, Ohio; Nashville, Tenn.; Belvidere, Chicago, Harvey and Murphrysboro, Ill.; Indianapolis and Terre Haute, Ind.; Decarah, Dubuque, Iowa City, Jefferson, Mason City and Waukon, Ia.; Detroit and Houghton, Mich.; Minneapolis, St. Paul and Owatonna, Minn.; Beloit, Wis.; Lincoln and Omaha, Neb.; St. Louis, Mo.; Topeka, Kan.; Corsicana, Houston, San Antonio, El Paso and Waco, Tex.; Denver and Colorado Springs, Col.; and Seattle, Wash.

The demand system of charging, as already said, tends to make the charge to the customer proportional to the cost. It does not reach absolutely any such result, but even when least well devised it is a long step in that direction.

The fundamental principles are as follows:—

Instead of basing the charge to the customer altogether on the amount of his consumption, as is done with the flat meter rate system, or altogether on the size of his demand, as is roughly the idea of the contract system, the charge is based on both the consumption and the demand. The demand system recognizes that there must be a charge on consumption to prevent waste and that there ought to be a charge also on maximum demand, since to the maximum demand the largest part of the expenses of the station are proportional.

It has been already stated that from 15 to 20 per cent. of the expenses of a station are proportional to output and from 50 to 60 per cent. are proportional to maximum demand. Therefore, by making a charge both for consumption and maximum demand, the total charge will be proportional to a part of the expenses represented by the sum of the above percentages, that is, from 65 to 80 per cent.

As compared with the flat meter rate system then, the demand system approaches far more nearly the truly equitable condition of rates proportional to cost, and is also decidedly superior in this respect to the contract system, while it does not, as does the latter system, tend to encourage waste.

There are, however, from 20 to 40 per cent. of the expenses of a central station which are proportional neither to maximum demand nor to consumption, and if one or more other quantities could be found to which these expenses were proportional, it would be possible by making a charge also on these quantities to approach even more nearly to proportionality to cost.

This, however, it has not been found practical to do except to a limited extent, as will later be shown, and consequently it is necessary to charge the remaining 20 to 40 per cent. of the expenses either on the maximum demand or on the consumption, or to divide it between them in whatever manner seems most advisable. For example, let us suppose that in order to cover the expenses proportional to maximum demand, it is necessary to charge the customer $50 per year per kilowatt of his maximum demand; and in that order to cover the expenses proportional to output it is necessary to charge the customer 2 cents per kilowatt-hour. To one or both of these rates we must now add enough to cover the additional 20 to 40 per cent. of floating expenses.

This will result in modifying our demand system, so that instead of having charges of $50 per year per kilowatt and 2 cents per kilowatt-hour, we may have perhaps $55 per kilowatt per year and 6 cents per kilowatt-hour, or perhaps $60 a year per kilowatt and 4 cents per kilowatt-hour.

Briefly, then, we may say that a demand system is one in which the rates are based on two units, the unit of maximum demand and the unit of consumption, and further, that if these rates are made correctly the total charge to the customer will be much more nearly proportional to cost than it could possibly be with the contract or the flat meter rate system.

Returning for a moment to the contract system, it is evident since the whole charge is per unit of maximum demand that the rate per kilowatt-hour varies, being dependent on the number of hours' use of the maximum demand. On the other hand, with the flat meter rate system the rate per unit of maximum demand varies, being dependent also on the number of hours' use of the maximum demand.

If, therefore, the contract system is discriminatory, because under it the rate per unit of consumption varies, then the flat meter rate system is also discriminatory, because under it the rate per unit of maximum demand varies. The fact is that it does not follow that there is discrimination because the rate per unit of consumption, per unit of maximum demand, or per unit of any other quantity is different to different customers. If

the charge is to be proportional to cost, these rates must necessarily vary.

With a demand system under which the charge is based on both the maximum demand and the consumption, the average rate per unit of consumption and the average rate per unit of maximum demand both vary, and it is interesting to note that the customer who gets the lowest average rate per unit of consumption gets the highest average rate per unit of maximum demand, and conversely, the customer who gets the highest average rate per unit of consumption gets the lowest average rate per unit of maximum demand.

To see this clearly, let us assume that a demand system has been adopted and that the rates to be charged are $43.80 per year or 12 cents per day per kilowatt of maximum demand and 6 cents per kilowatt-hour. If a customer is charged on this basis and has a maximum demand of 1 kilowatt and a consumption per day of 1 kilowatt-hour, his total charge per day will be 12 cents for his maximum demand, plus 6 cents for his consumption, amounting to 18 cents. His average rate per day per kilowatt will then be 18 cents, as will also be his average rate per kilowatt-hour.

If the customer consumes 2 kilowatt-hours per day, his total charge will be 12 cents for his maximum demand as before, plus 12 cents for his consumption, or 24 cents, and his average rate per day per kilowatt will have risen from 18 cents to 24 cents, while his average rate per kilowatt-hour will have fallen from 18 cents to 12 cents.

Fig. 1 is a diagram showing the variations, with the above charges, in the average rate per kilowatt of maximum demand and in the average rate per kilowatt-hour, as compared with variations in the number of hours' use of the maximum demand.

The abscissae or horizontal values represent hours' use per day of maximum demand. Curve No. 1 shows the variation in the rate per kilowatt-hour, curve No. 2 the variation in the rate per kilowatt per day. The ordinates or vertical distances represent cents per kilowatt-hour for curve No. 1 and cents per day for curve No. 2.

We see at a glance that the average rate per kilowatt-hour falls off rapidly at first with increase in the number of hours' use of the maximum demand, then decreases more slowly and approaches 6 cents as a minimum. The average rate per day per kilowatt, on the other hand, steadily increases with increase in hours' use of the maximum, starting at a minimum of 12 cents per day.

With this diagram before him, how can anyone say that A is discriminated against simply because B gets a lower rate per kilowatt-hour? Can he not with equal justice claim that B is discriminated against because A gets a lower rate per kilowatt of maximum demand?

We have now shown that since under a demand system of charging, the charge to the customer is more nearly proportional to cost than with either of the old systems, consequently the demand system is really less open to criticism by the public than either of the old systems. The writer has not claimed, however, that the companies which have adopted the demand system of charging have done so on abstract grounds of justice. On the contrary, they have done so for reasons of expediency. They

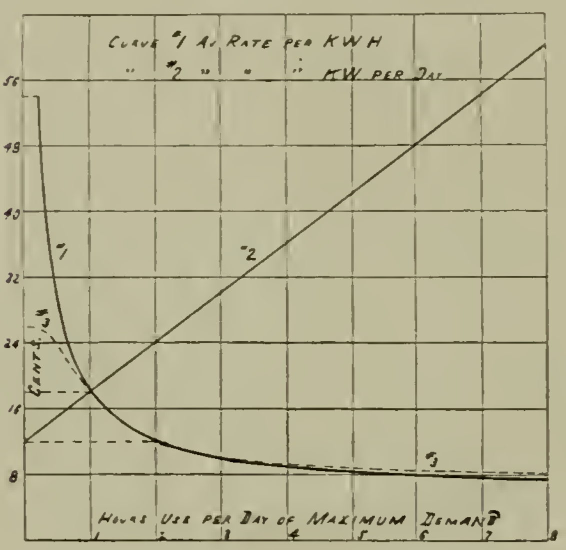


FIG. 1.

have realized that with such a system they can increase their profitable business.

But not only is this system best for the electric light companies, it is also best for the public, since it results in lower average prices. Suppose, for example, that a company is operating with a demand system of rates, the highest rate per kilowatt-hour that a customer is charged being 20 cents and the lowest rate 5 cents. Let us also suppose that the average rate with this system is 10 cents per kilowatt-hour. If the company adopts a flat rate of 10 cents (that is a rate equal to the average rate on the demand system), what will be the result?

Certainly the customers who were previously charged a higher price than 10 cents will all stay with the company, the income from them being reduced. On the other hand, some of the customers who were getting a lower price than 10 cents, because they were long-hour customers with good load factor and therefore profitable even at a low rate, will cease to be customers, either going to the gas company or putting in plants of their own.

As a result, having lost a large number of its customers, and the income from those that remain being reduced, the company will be obliged, if it wishes to continue the flat rate and at the same time avoid bankruptcy, to raise that flat rate from 10 cents to 12 cents or more. Both the company and the community as a whole, therefore, will suffer from the higher average rate.

FORMS OF THE DEMAND SYSTEM

It will now, perhaps, be interesting to describe some of the various forms under which a demand system may appear, in order to see how they may differ in appearance and yet be fundamentally the same. In Fig. 1 has already been shown the relation between the average rate per kilowatt-hour and the number of hours' use of the maximum demand on the assumption of a charge of 12 cents per day, per kilowatt of maximum demand and a charge of 6 cents per kilowatt-hour.

We can, however, obtain practically the same results with charges stated in a very different way. For instance, if we make a rate of 18 cents a kilowatt-hour to be charged on a consumption equivalent to 1 hour's use per day of the maximum, and a rate of 6 cents per kilowatt-hour on all consumption in excess, we shall get a curve identical with the one shown except that it will not rise above 18 cents, the maximum rate, but for any consumption less than one hour's use of the maximum, it will become flat.

Again, if we make the rate 12 cents a kilowatt-hour for the first two hours' use of the maximum and 6 cents for all in excess, we shall have the same curve except that it will be flat at the maximum of 12 cents for all use less than two hours. This is the most commonly used form of the demand system and was invented by Arthur Wright, and is conveniently known by his name.

The direct charge of so much per kilowatt-hour and so much per kilowatt already described was first suggested by Hopkinson in England, and is there, the writer believes, called by his name, but in this country it is generally known as the "Readiness to Serve" system. The Hopkinson and Wright systems accomplish nearly the same result, and one is convertible into the other except for the fact that the Wright system fixes a maximum rate per kilowatt-hour.

The maximum or primary rate on

the Wright system can, however, be set as high as we please and the number of hours' use at the primary rate correspondingly reduced, and in this way we can make the Wright system approach as closely to the Hopkinson system as we wish. For instance, if we take the charges assumed for the diagram, Fig. 1, and make the primary rate on the Wright system 54 cents per kilowatt-hour to be charged on one-quarter of an hour per day's use of the maximum demand, we shall approach very closely to the Hopkinson system, as will be seen from the diagram.

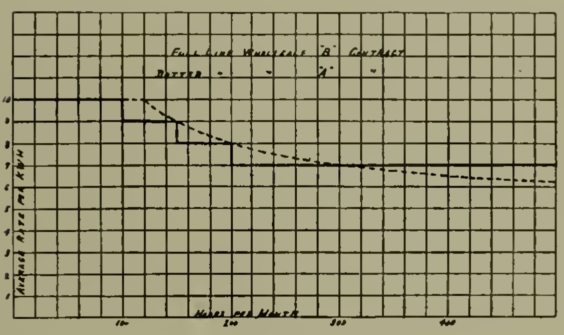


FIG. 2.

Mr. Wright was led to adopt his form of demand system because in Brighton, England, his maximum rate per kilowatt-hour was fixed by law at 14 cents. He would have preferred the corresponding Hopkinson form, which he thought made the rates very closely proportional to cost, and he felt that at the 14-cent rate he was losing money on many short-hour customers.

This would appear to be true if we look at the diagram. It would certainly seem, if the curve based on a certain demand charge and a certain consumption charge is nearly proportional to cost, as it is supposed to be, that with a maximum rate fixed, some of the short-hour customers would be losing customers, since they would not pay what they ought to as shown by the curve.

This is a condition of affairs, however, which must be put up with, because in many places the maximum rate per kilowatt-hour is fixed by law, whether wisely or unwisely, and cannot, therefore, be exceeded, but this fact is not so unfortunate as it would at first sight appear, if the following considerations are taken into account.

The maximum demand of a long-hour customer is much more likely to coincide with the station peak than is the maximum demand of a short-hour customer. If we imagine a customer who uses his maximum demand continuously throughout the year, then clearly his maximum demand is always on at every moment of time and must therefore coincide with the station peak.

If his use of the maximum is anything less than the continuous it is possible that his demand at the time of the station peak may be less than his maximum demand for current. Under conditions as they are, however, the probability is very strong that if the maximum demand of any customer is used on an average as much as seven or eight hours per day, it will coincide with the station peak.

On the other hand, if a customer uses his maximum demand on the average only an hour or two a day, there is a strong probability that his demand at the time of the station peak will be but a small fraction of his maximum demand. If, then, the short-hour customers, as a class, are less likely to add to the station peak than are the long-hour customers, they might fairly be charged less per unit of maximum demand.

It is a difficult problem in the theory of probabilities, however, to calculate what relative reduction the short-hour customers should get. There should probably be a reduction increasing slowly at first with reduction in hours' use, but finally increasing rapidly when the time of use is as short as one or two hours per day. Such a reduction in the rate per unit of maximum demand to short-hour customers would result, of course, in the average rate per kilowatt-hour being somewhat lower to them, and it is likely that the curve of average rate, instead of having the form shown, would be more like curve 3.

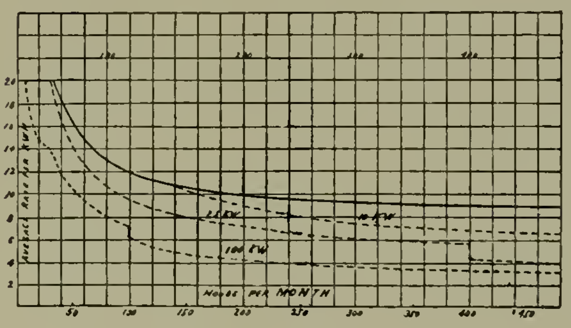


FIG. 3.

It will be seen that the first curve can be made to very closely resemble this if a maximum rate per kilowatt-hour is charged for all consumption equivalent to less than a given number of hours' use of the maximum.

We will now take up some of the demand systems actually in use and point out their fundamental similarity. In Fig. 2 is shown the effect of what are known as the wholesale "A" and "B" contracts offered by one of the large Edison companies. With these contracts, maximum demand is assumed equal to the connected load.

The dotted curve shows the average rate per kilowatt-hour in relation to the number of hours' use of the maximum with the "A" contract, and from it we see that the rate per kilowatt-hour is 10 cents for all consumption not exceeding 120 hours' use per month. Wright's method is used in presenting this contract to the customer, that is, he is offered a rate of 10 cents a kilowatt-hour, the maximum permitted by law in this case, on a consumption equivalent to four hours' use per day (120 hours' use per month) of his maximum, and a 5-cent rate per kilowatt-hour on all consumption in excess.

Hopkinson's method of expression might have been used with the same result, in which case the rates would have been as follows:—$73 per year per kilowatt of maximum demand, and 5 cents per kilowatt-hour with a proviso that the average rate per kilowatt-hour should not exceed 10 cents.

The full curve shows the effect of the wholesale "B" contract of the same company. With this contract, the customer is offered a 10-cent rate per kilowatt-hour up to a consumption equivalent to 100 hours' use per month of his maximum demand. If his consumption exceeds 100 hours' use and is less than 150, his rate on all his consumption becomes 9 cents. If it exceeds 150 hours' use and is less than 200, his rate becomes 8 cents, while if his consumption exceeds 200 hours' use, his rate is 7 cents.

It will be seen that with the "B" contract, the result is on the average nearly the same as with the "A" contract. With the "A" contract, however, the rate falls gradually, while with the "B" contract it drops in a series of steps, with the unfortunate result that a customer can get a smaller bill sometimes if he uses a little more current.

This difficulty will always arise if a discount or low rate, when earned, is given on the whole bill. It is avoided when the discount is made to apply only to the excess of the bill beyond the earning point of the discount. If the discount is given on the whole bill it is known as a "step" system of discounts; if on the excess of the bill it is known as a "block" system of discounts.

Both the Hopkinson and Wright demand systems of charging are "block" systems in effect. The "B" contract above mentioned is a "step" demand system, and cannot be expressed either in Hopkinson's or Wright's form. It is an awkward system to handle.

The full curve in Fig. 3 shows the contract rate of another large Edison company. Here again the rates are expressed in Wright's manner, namely, the customer is to pay for 400 hours' use per year (figured in the diagram as $33\frac{1}{3}$ hours per month) of his maximum demand at 20.2 cents a kilowatt-hour and for all in excess at 8 cents per kilowatt-hour.

As it is optional with a customer, however, to take current either under a contract, or without a contract at a maximum rate of 18 cents a kilowatt-hour, 18 cents rather than 20.2 cents should be considered the maximum rate. These rates might have been stated in the Hopkinson manner as $48 per year per kilowatt of maximum demand, and 8 cents a kilowatt-hour with a maximum average rate per kilowatt-hour of 18 cents.

We come next to the rate system of a prominent Western company which is interesting partly because this company expresses the charge in the Hopkinson manner, but more particularly because it bases a part of the charge on a third unit as well as on maximum demand and on consumption. The charges are as follows:—$1.80 per year per lamp of maximum demand (equal to $36 per year per kilowatt of maximum demand), 5 cents per kilowatt-hour and a service charge of $1 per month.

This last charge is made on the assumption that a part of the expenses are directly proportional to the number of customers and should therefore be divided directly among the customers at so much per head. This is justifiable, as there probably are expenses amounting to perhaps 10 per cent. of the total which are proportional to the number of customers, such as clerical work in making out bills, and keeping customer's accounts, meter reading, etc., and it is truly scientific to make a separate charge to cover them.

Most companies, nevertheless, prefer to cover this expense by a slight additional charge per kilowatt-hour and a minimum bill of $1 or $2 per month. The last mentioned company also offers a 10-cent flat meter rate which is of course equivalent to making its maximum rate 10 cents, and the rates can therefore be expressed in Wright's form if desired, and in that form are as follows:—10 cents a kilowatt-hour on a consumption equivalent to 60 hours' use per month of the maximum demand, and 5 cents per kilowatt-hour for all consumption in excess, plus $1 per month.

WHOLESALE DISCOUNTS

Wholesale discounts, that is, discounts for quantity of consumption, are often given with a demand system. Such discounts are justifiable, as there is no doubt that a large consumer can be supplied at a lower rate per kilowatt-hour than a small consumer with equal or greater profit. There is no justification, however, in using a system of wholesale discounts only, as a substitute for a demand system, because such a system of wholesale discounts takes no account whatever of the hours of burning, the most potent factor effecting the cost of supplying a customer.

A system of purely wholesale discounts discriminates in favour of a few large short-hour consumers at the expense of numerous small long-hour consumers. On the other hand, the demand system combined with wholesale discounts gives the lowest rates per kilowatt-hour to the large consumers who at the same time are long-hour users, while it gives the highest rates to the small short-hour consumers.

When wholesale discounts are given they should be given on the "block" system. A Hopkinson or Wright demand system combined with wholesale discounts on the "block" system is probably the best system of rates that has yet been devised. The second of the large Edison companies referred to above gives wholesale discounts on the "block" system, as follows:—40 per cent. discount on excess of bill over $150 and up to $550, and 50 per cent. discount on excess of bill over $550.

There is also a "step" wholesale discount if total consumption reaches 10,000 lamp-hours, approximately 500 kilowatt-hours, or more per month. In this case the secondary or low rate is 5 cents per kilowatt-hour instead of 8 cents. The full curve in Fig. 3 shows the rate without wholesale discounts, that is, the rate for small consumers. The dotted curves show the effect of the wholesale discounts for customers with maximum demands of 10, 25 and 100 kilowatts, respectively. The good effect of the "block" discounts is shown by the smooth curves. The bad effect of the "step" discount appears in the curves of the two larger customers.

MAXIMUM DEMAND

In the foregoing discussion of demand systems of charging there is one very important question which has not been touched upon, but has, in fact, been very carefully avoided, in order not to complicate the discussion. This question is, "What shall be considered to constitute the customer's maximum demand and how shall it be determined?

It is the practice of some companies to assume that the customer's maximum demand is the maximum demand possible, which is, of course, the connected load. This practice is open to very grave objections, and the principal one is that the customer's connected load is an unfair basis of charge. It has already been shown that a demand system of charging approximates a system in which the rate is proportional to the cost, but we immediately depart from the principle of rate proportional to cost if we undertake to assume that the customer's connected load represents his maximum demand.

It is the actual maximum demands of the various customers which determine the plant capacity and not the number of lights, motors or other apparatus which are connected if these are never all in use simultaneously. One customer's maximum demand may be only one-half his connected load, while another's may be the whole of his connected load. It is manifestly unjust that the demand charge to them both should be the same. There are also numerous practical objections to the use of the connected load as a basis of charge.

At the beginning of a contract, a customer's premises can be inspected, the number of outlets can be counted, the candle-power of the lamps of the capacity of other apparatus connected to each outlet can be noted, and in this way the connected load ascertained. But after the connected load is once ascertained, it becomes necessary to require the customer to agree to make no change in his installation without notifying the company.

Such a requirement is objectionable, insomuch as it seriously impairs one of the great advantages of electricity, namely, its flexibility of use. The customer cannot change the candle-power of his lamps, substitute a fan or heating device in place of a lamp, nor connect apparatus to an outlet not in use before without consulting the company.

Furthermore, in spite of agreements to the contrary, a customer either willfully or through ignorance of his agreement will often make changes without notifying the company, and the latter has no means of knowing when this is done unless frequent inspections of the customer's premises are made. Such inspections are an intrusion on the privacy of a customer and are sure to be an annoyance to him. Also, if they are made frequently enough to be of any use, they become a heavy expense to the company.

Another objection to the use of the connected load as a basis of charge

is that it discourages the extensive use of electricity. If a customer is to be charged for every additional piece of apparatus connected, he will be inclined to connect as few as possible, and may even go as far as to use electricity in certain parts only of his premises and in other parts to use other means of obtaining light and power. In the case of power, the customer will be inclined to install as small a motor as he can possibly get along with, the result being overloading, perhaps, and consequently poor service and dissatisfaction.

It is safe to say, however, that there are but very few companies in the United States to-day which make use of the connected load as a basis of charge. There are a number that appear to do so, if we judge by their printed forms of contract with customers, but if investigation is made it will be found in almost every case that the word "lights," "installation" or "H. P." occurring in the contract form is not taken to mean "all the lights," the "total installation," or "rated horse-power," but is really the customer's maximum demand either estimated or measured by an instrument.

As just previously stated, the estimated demand is used as a basis of charge by many of the companies which appear to be using the connected load, and there are other companies which clearly make the estimated demand the basis of charge even in their printed contracts. This is better practice than the use of the connected load, as the actual maximum demand of the customer is a fair basis of charge.

The principal objection to this practice is, of course, that the estimate is liable to be inaccurate. In the smaller companies, a separate estimate can be made for each customer, but in the larger companies it is hardly practical to do this, and it is, therefore, usual to assume the average maximum demand for each class of customers as a certain percentage of the connected load as, for example, 40 per cent. for residence lighting, 75 per cent. for store lighting, and so on.

When such estimates are made with care by actual measurements in numerous cases, they may be considered to be fairly accurate, at least at the time they are made, but in all probability the average maximum demands of the different classes will not remain constant and the estimates therefore will cease to be of value. Further, even if the estimated average maximum demands have a high degree of accuracy, it must be remembered that after all they are merely averages, and it is quite possible that the maximum demand of any particular individual may be considerably higher or considerably lower than the average of his class, and consequently his rate will be either too high or too low.

The other objections to the use of the estimated demand are practically the same as for the connected load basis. Since the estimate must be based on the connected load, it is not possible to permit the customer to make changes unknown to the company. This necessitates frequent inspections of the customer's premises, which, as before stated, are an annoyance to the customer and an expense to the company. Also in order to keep the estimate of his demand low, the customer will be discouraged from extending his connected load.

Measuring the customer's demand with an instrument is a practice which has numerous advantages, the first of which is that the demand can be obtained with accuracy. Further, a customer can freely make changes in his apparatus installed without stopping to notify the company, as his demand will be recorded on the instrument. For the same reason no inspections of the customer's premises are necessary other than the ordinary ones to see if the installation is safe and that no connections are made back of the measuring apparatus.

The maximum demand indicator also acts as a guide in determining the proper size of watt-hour meter and, if this information leads to the use of smaller watt-hour meters, there may be a considerable reduction made in the loss due to their slow running or stopping when operating on light load. Another advantage of the measured demand is that the customer need not hesitate to connect as much apparatus as he wishes. The demand indicator will show only the power supplied to such apparatus as may be simultaneously in actual use.

The disadvantage of the measured demand is, of course, the necessity of using an instrument. This means, in the first place, the expense of purchasing and installing, and afterwards, expense of maintaining, reading and resetting. Also additional resistance is introduced into the line, absorbing energy and injuring the regulation.

Still, these arguments could also be urged against the use of the watt-hour meter, and they are not valid if in the actual instruments used these objections are reduced to a minimum, which is the case. Demand indicators with capacity up to 25 amperes, can now be purchased for close to $6, and even large instruments of several thousand amperes capacity cost only about $30 or $40. In addition they are simple to install, cost very little for maintenance and absorb but a trifle of energy.

If the customer's maximum demand is to be measured, the question will arise as to just what shall constitute this maximum demand. Under a yearly contract it would seem that it should be taken as the highest reading of the indicator for the year. Objection, however, is generally raised to this practice on the ground that a customer may on some special occasion have a demand greatly in excess of what is usual, and it is argued that as on such an occasion the demands of his neighbours are probably less than usual he should not be charged with the unusual demand.

This objection certainly has some force, and there are ways of avoiding it, but before taking these up let us compare the annual maximum demand of the customer with the connected load as a basis of charge. This is done for the reason that the above objection to the measured demand has been occasionally raised by gentlemen who are using the connected load as a basis of charge.

The annual maximum demand of a customer, no matter how much in excess of the usual demand, can never exceed the connected load and may not be as great. If, therefore, the above objection applies to the annual maximum demand as a basis of charge, with how much more force does it apply to the connected load?

In presenting to the customer a contract based on the annual maximum demand, it should be impressed on him that the charge is based on the number of his lamps, but that a concession is made by the company if during the course of his contract he never uses all his lamps simultaneously.

The company can put it this way, "We realize that in the course of the year it is possible that you will not use simultaneously all your lamps, and if such is the case we will give you the benefit of that fact by basing the charge to you on the maximum number of lamps simultaneously in use, as shown by the reading of the demand indicator." If this is done, the customer will look upon the demand indicator as a device for lowering his bills.

As already stated, however, the writer believes that the above mentioned objection has some force. Some companies try to avoid it by a clause in the contract in which they agree to cut out the demand indicator for a limited number of special occasions, provided the customer gives

them due notice. Often, however, the customer forgets to give notice, and in any case the necessity for a notice is a nuisance.

A better way to overcome the objection is to base the charge to the customer on the average of several months' readings of the indicator. In this way the effect of an unusual demand is spread over several months and thereby mitigated. If this is done, however, it is possible that the customer may have no demand or a very small demand during one or more of the months in question, with the result that his average reading will be too low. For this reason it should be specified that in no case shall the average reading be taken as less than a specified percentage of the maximum reading.

There is one other point which must be mentioned in connection with the measured demand whether the demand is taken as the highest reading of the indicator for the year or as the average reading of several months; this is, that until the readings can be taken, the demand must be estimated.

This, however, is only necessary in the case of new customers and is not a serious matter in any case, as the estimate only has to be used but a few months as a rule and in no case for more than a year. With old customers whose demand has been fixed in the year just passed, this demand can be continued in force until the new measurements are obtained.

When a yearly contract cannot be made with a customer it is still possible to have some of the advantages of a demand system with measured demand by basing the demand charge on the monthly maximum. This makes a simple system, as the estimate above mentioned does not have to be made, and the customer's bill is determined wholly by the monthly readings of his demand indicator and watt-hour meter.

Some companies combine the measured demand with the estimated demand. Instead of installing a demand indicator on all their customers except the smallest (generally a company cannot afford to assume the maximum demand of its smallest customers as anything less than the connected load), a company will use the indicators to check doubtful estimates, or as a means of detecting an unwarranted extension of connected load. With this method, the indicator is not necessarily permanently installed, but may be moved about from one customer to another.

Still another practice is to determine the maximum demand by agreement with the customer and then to make it impossible for him to exceed this demand. As it would not be expedient to use any means of limiting the customer's demand, which would actually cut off his service, the limiting is done usually by means of a device which will cause his lights to flicker the moment the agreed upon demand is exceeded.

This practice, as compared with the measured demand, has the advantage of positively determining the demand in advance, and it avoids the indicator readings necessary with the measured demand. It has the disadvantage of causing irritation when a customer on an occasion wishes to exceed his demand and finds he cannot do so. The owner of a large residence would probably resent any interference with the use of such lights as he might at any time turn on, and it would nevertheless be difficult to make him agree to a demand very much higher than what he usually expected to have.

On the other hand, it may be said that many small customers would prefer to have their demand fixed and thus be prevented from inadvertently exceeding it, thereby raising their bills. It would seem, therefore, that a judicious use of both the measured demand and the limited demand methods of charging might be found advantageous. For example, the measured demand could be made the regular practice, but the option of the limited demand might be given.

Writing to "Engineering," of London, a correspondent in India makes the following inquiry:—"We have a number of elephants in the State. I propose to utilize them in working dynamos for six hours every day and generate electricity, to store it in batteries and use it at night for lighting streets. I shall feel obliged if you will please give me the information required in the statement accompanying:—(1) How many electrical units will an elephant of ordinary strength, working six hours, produce? (2) Cost of dynamos required. (3) Cost of gear required to work it by elephants. (4) Cost of battery to store the electricity." In reply, among other things, "Engineering" says:—"We do not suppose elephants could be trained to raise water in their trunks and spurt it on a Pelton wheel; and as we have no means of calculating the force of a jet of this kind, we are not able to recommend this means."

Canada has 13 wireless telegraph stations along the coasts of the eastern provinces.

The Production of Red Rays in the Mercury Vapour Lamp

ACCORDING to the "Electrotechnische Zeitschrift," tests made by E. Gehrcke and O. Von Baeyer for producing red rays in mercury vapour lamps, consisted in modifying the working material of the lamp by employing amalgams in place of pure mercury. If a tube of amorphous quartz is used with electrodes of an amalgam of 100 parts of zinc with 30 parts of mercury by weight, it is found that besides the ordinary mercury lines there are also strong zinc lines present in the spectrum. The red zinc line is especially prominent, and the light of such a lamp approximates much more closely to natural daylight than that of the ordinary mercury lamp does.

Red sealing wax appears red, and the human skin appears, if anything, rather too rosy. Only the yellow effects remain distorted, and appear either too ruddy or too green. To correct this last effect, a little of the metal sodium was added to the zinc amalgam, and the result was then very satisfactory, the light given being similar to that of many Bremer flame lamps.

The zinc amalgam is solid at ordinary temperatures, and clings to the surface of the tube; and in order to avoid cracking the latter through excessive expansion of the amalgam, it was further found advantageous to add about 10 per cent. of bismuth. The presence of the bismuth did not appreciably affect the colour of the light. The length of arc employed in these experiments was about 10 centimeters.

Tuning a Piano by Means of the Telephone

THE novel feat of tuning a piano by the use of the telephone, according to "The American Telephone Journal," was accomplished by M. J. Archer, a piano tuner of Wabash, Ind. Some time ago Mr. Archer sold a piano to Thomas Pilkington at South Bend. Miss Pilkington called Mr. Archer up and advised him the piano needed a tuning. She was asked to sound the instrument, which was near the telephone. The tone was transmitted clearly to Wabash, and directions were given which enabled her to change the tension. The directions were carried out, and the instrument repeatedly sounded until it was perfectly tuned and the tones all normal.

Electricity in a Modern Shipyard

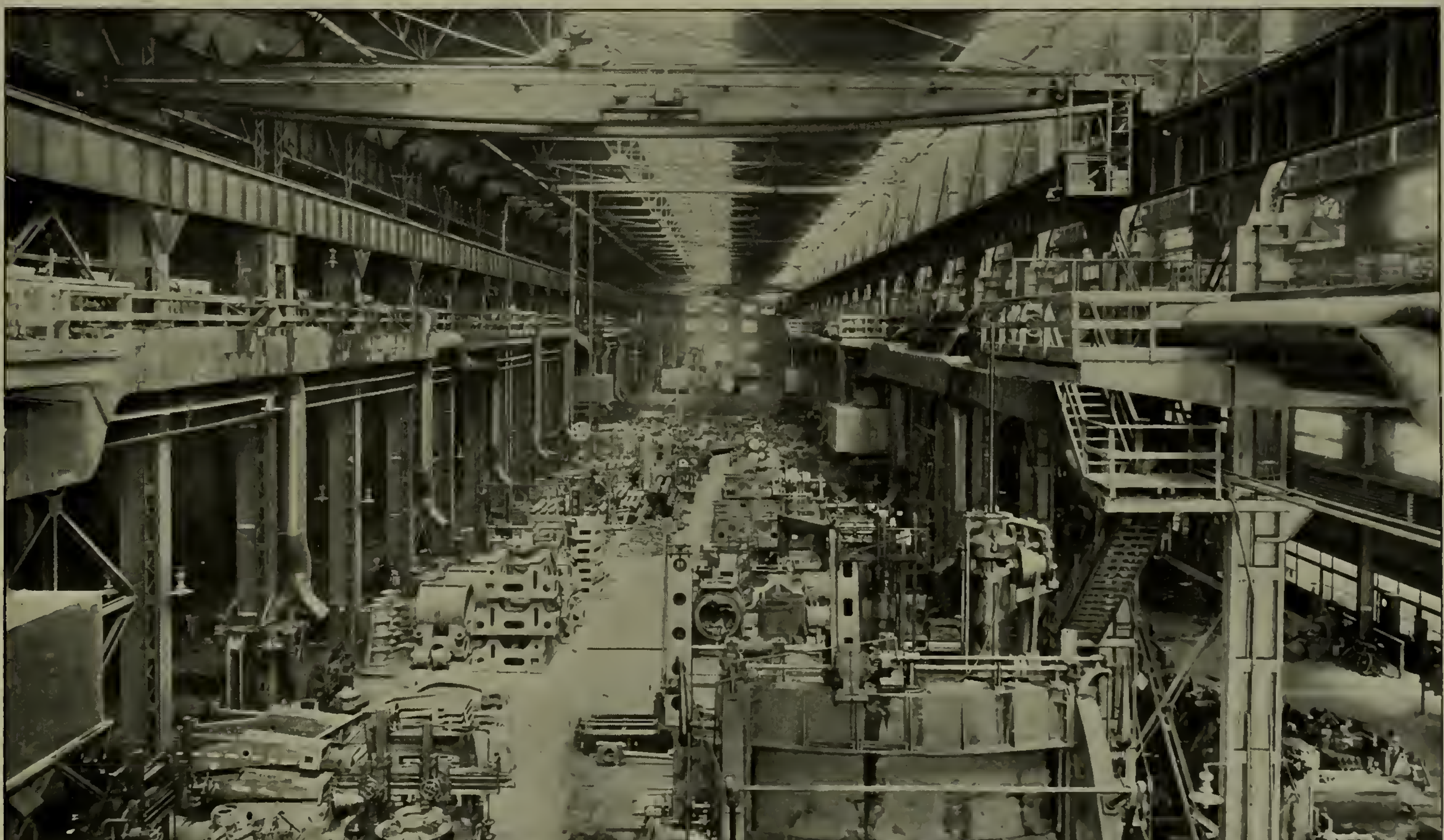
The Plant of the New York Shipbuilding Company, at Camden, N. J.

By A STAFF CORRESPONDENT

WHERE the conditions in manufacturing have not been such as positively to compel the development and use of means for quickening production and cheapening cost, and where the introduction of thoroughly modern methods would have involved heavy expense, it is perhaps not astonishing that the "scrapping" process has not been adopted with great zeal. This has been true in great measure of the shipbuilding industries on both sides of the Atlantic, though there are notable exceptions of old-established plants in which some of the best improvements have been quickly turned to account.

In the case of an entirely new shipyard, however, it might be expected that the plant would be laid down along wholly modern lines, and that, in the matter of power equipment, extensive use would be made of electric transmission and driving. A splendid example of American enterprise of this kind is found in the plant of the New York Shipbuilding Company, at Camden, N. J. This installation is modern in every respect; all the buildings have been put up within the last five years; the equipment was entirely new; many of the machines were designed especially for these works, and the entire organization, plan of operation, shop methods, etc., were worked out to meet the special requirements of this concern. It was a large undertaking, but the company had the experience of older establishments to guide it, and, moreover, the management, under the leadership of Henry G. Morse, included in the organization many of the ablest engineers of the country, all of them especially qualified to solve the problems of their respective departments. The electrical features were under the direct supervision of Prof. W. L. Robb, who acted as consulting electrical engineer for the shipbuilding company.

An idea of the originality, extent and completeness of the company's system and methods may be gained when it is explained that, with the exception of the power plant and the joiner shops, the entire establishment, which gives employment to 4000 men, is under one roof; that the material which enters the plate and storage rooms at one end of the yard does not leave the building until it goes out as a part of the completed ship for which it was intended, when

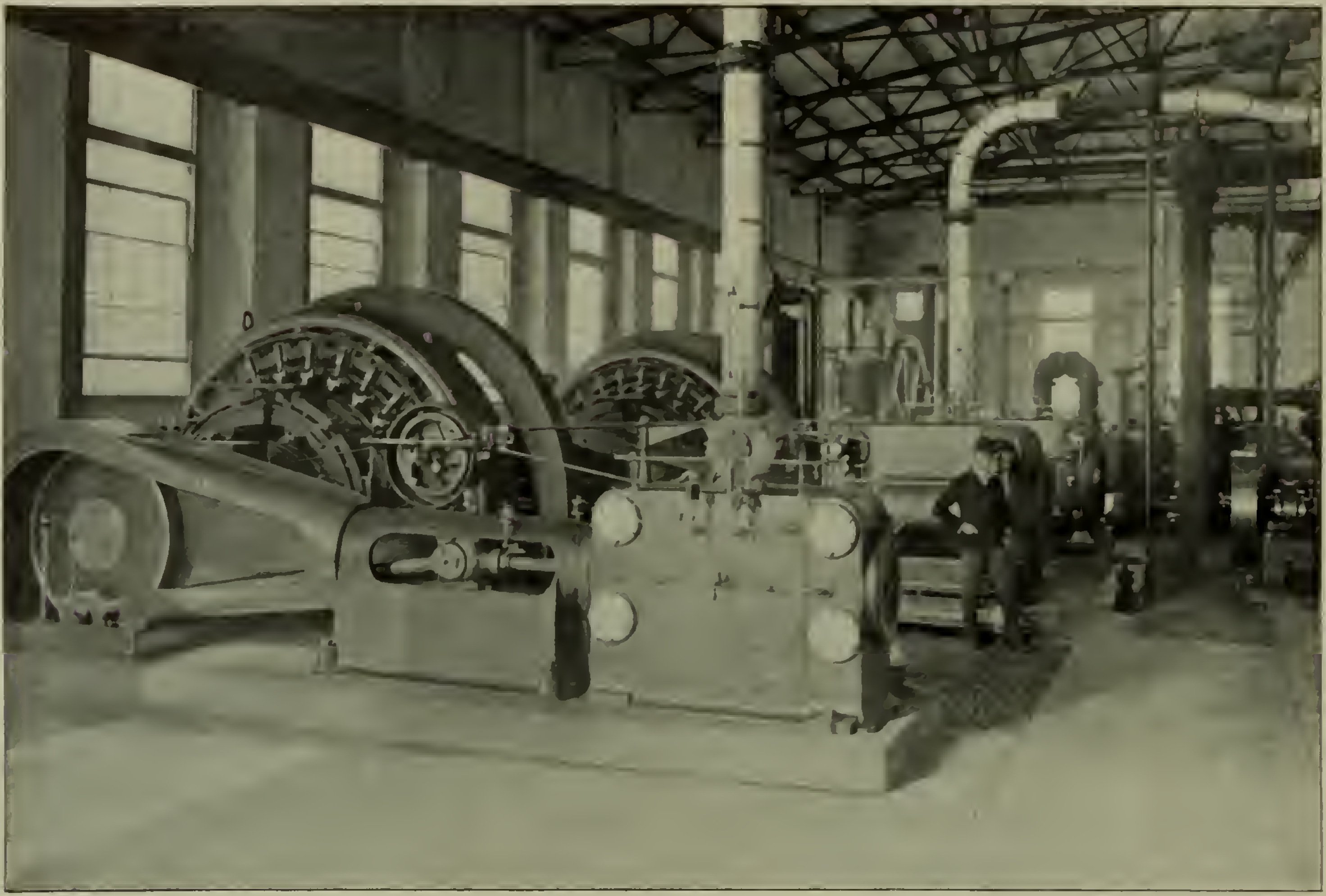


A VIEW OF THE MACHINE SHOP OF THE NEW YORK SHIPBUILDING COMPANY AT CAMDEN, N. J. WITH THE SYSTEM OF INDIVIDUAL ELECTRIC DRIVING OF THE MACHINE TOOLS, THE FREEDOM FROM OVERHEAD SHAFTING AND BELTING IS CONSPICUOUS

the vessel is ready to enter service; that there are installed in one main building and under one roof all the material and machinery necessary for the construction of the largest ship known to commerce, and that eight sets of ship ways, built upon masonry foundations, covered by roofs of steel and glass and spanned by cranes up to 100 tons lifting capacity, are practically as much a part of the immense main building as the boiler shop or machine shop.

About 3600 feet of river frontage, a machine shop with four acres of floor space, and a storage house for 20,000 tons of plates and shapes, are features of the works. The plant has the operation of many machines hitherto driven by compressed air, steam, or hydraulic power. An elaborate system was, therefore, worked out, providing for the generation, transmission, and distribution of electricity on a large scale and in the most economical manner. As has already been mentioned, the power house is entirely distinct from the main building, and the joiner shop is likewise entirely isolated; thus, by keeping the steam plant in a separate building, the company has succeeded in removing as completely as possible all danger of fire. All the power used in the works,—compressed air, hydraulic, and electric,—is generated in sequently, provision had to be made for generating both direct and alternating currents, and to meet these requirements double-current generators of the type shown in the view of the power pouse on this page were adopted. They comprise two direct-connected, 500-kilowatt Westinghouse generators delivering current at 250 volts and 3000 alternations, when operated at 120 revolutions per minute.

These machines resemble standard rotary converters for transforming alternating current into direct current or direct current into alternating current, but were modified in this case to be operated by mechanical



A VIEW OF THE POWER HOUSE INTERIOR

been laid out to achieve economical results in the beginning—not merely to become economical with the growth of business. It can be extended and enlarged at will, as extension means little more than duplication of the existing parts; but, in its present condition, it is complete in every part, and may rightly be considered a finished plant.

The organization and the form and arrangement of the shops and departments contributed largely to the successful development of the project to introduce electricity in the operation of the plant on a larger scale than had ever before been attempted in shipbuilding. It was determined to depend mainly upon this form of power, and to utilize it in this power house, and thence transmitted to the several departments for use.

The most noteworthy feature of the power house equipment is the electrical plant, and this is particularly interesting because of the unusual character of the apparatus employed. In the selection of the system to be installed, the company's engineers were governed entirely by the special character of the service to be performed and by the local conditions that had to be met. It had been determined to employ direct-current enclosed arc lamps for illuminating the yards and shops, direct-current motors for operating cranes, and alternating-current motors for driving machine tools; consequently, power as generators, delivering both direct and alternating current at the same time, and with very satisfactory results. In appearance these double-end generators resemble direct-current generators, with the exception that collector rings are added. An important feature of these generators is that the proportion of alternating and direct current delivered is regulated by the demands upon the machine; thus, when there is a heavy demand for alternating current the proportion may be five-eighths alternating current and three-eighths direct current; or, when the demand for direct current is greater, the proportion is automatically reversed.

In the plan of the yards and the arrangement of the several depart-

ments an elaborate system of electric cranes was devised, including transfer tables, by means of which it is possible to put all departments in communication, so that from the time the material enters the yards until it leaves them as a part of the ship it is handled entirely by cranes. The material is received on the yard railway, which comprises about six miles of track within the company's enclosure, practically none of which, however, enter the buildings. A wing of the building is devoted to the unloading of cars, and tracks have been laid in this extension for a distance of 500 feet. Experienced shop managers will appreciate the advantage of an arrangement which makes it unnecessary to cut up the floors with tracks, take up valuable space with runways, and obstruct the building with freight cars, besides obviating the inconvenience of having locomotives enter the buildings. The receiving station for material is the plate storage shed at one end of the yard, and at right angles is the main building, which, under one roof, and that 150 feet above the ground, includes the machine shop, boiler shop, blacksmith shop, frame shed, plate shop, general storehouse, brass shop, pipe shop, copper, tin and light plate shop, mould loft, building ways, and outfitting slip. These have a floor space of eighteen acres, and are lighted by four acres of skylights and two acres of window surface. When the cars are unloaded in the wing the material is taken by a twenty-ton gantry crane to the place assigned it, the plates being arranged on end in racks, as shown in the view of the plate shop on this page. As the plates are required they are picked up by the crane and carried to the straightening or bending rolls or other tools at the end of the shed.

The large gantry crane shown on this page operates in the yard just outside of the building, and, entering the wing, travels the entire length of the storage plate shed, crossing the end of the boiler, angle, and plate shops. It has a span of 88 feet and a lift of 22 feet. There are two ten-ton trolleys equipped with chain hoists and lifting magnets, and it can span two freight cars lengthwise. Each trolley is provided with a 25-horse-power street car motor to lift the full load 20 feet per minute, and a 2-horse-power enclosed crane motor to traverse the trolley along the bridge, which is moved along the runway by two 25-horse-power street railway motors operated in series-parallel. This gantry is really a feeder for the extensive system of

AN 88-FOOT SPAN GANTRY CRANE, WITH LIFTING MAGNETS FOR HANDLING PLATES

thirty-five electric overhead travelling cranes in the shops, ranging in lifting capacity from 5 to 100 tons and operated by motors aggregating 2000 horse-power.

The huge 100-ton crane within the shop is carried on a span of 121 feet and its field of operation covers the machine shop, ways and slip, so that it may be employed to lift an engine or boiler bodily from the machine shop and deposit it in a vessel under construction, either on the ways or afloat. The crane has two trolleys, each capable of lifting fifty tons at 8 feet per minute, and each provided with a 50-horse-power street railway motor. The height of the lift is 115 feet, and each load is carried by eight parts of wire rope Each trolley is traversed in the bridge by a $7\frac{1}{2}$-horse-power enclosed crane type motor. The bridge, with its 121-foot span, is carried upon 24-inch steel-tired bridge wheels in equalizing trucks. Two 35-horse-power street railway motors with series-multiple controllers are provided for its travel.

Each of the smaller cranes has its own field of operation, and an original type has been installed, which, by means of an extension arm, is able to deliver and receive material from another crane without rehandling; in other words, it can reach beyond its ordinary field of operations into a parallel field and thus transfer material from one field to the other.

Cranes in the department handling plates are equipped with powerful lifting electromagnets, controlled by the operator in the cage. The advantage of this arrangement is that instead of having to employ half a

PLATE RACKS WITH OVERHEAD CRANE SERVICE

ONE OF THE EXTENSION-ARM CRANES

dozen labourers to lift the plate, with crowbars, while a chain is being slipped underneath and then to go with it to its place of deposit and release the chain by a similar process, only one man is required besides the operator. The latter brings the lifting magnet over the plate, turns on the current, and the plate, which thus becomes the armature of the magnet, can be lifted and carried to any place in the shop, and then instantly released by the turning off of the current. Sometimes several plates are picked up at the same time, and the operator by quickly opening and closing the switch can drop them one at a time, the residual magnetism in the lifting magnets holding the plates nearest them. Of course, considerable skill is required on the part of the operator to perform this feat.

An interesting part of the crane equipment is found in the extension-arm cranes. By means of the extension arm the crane may be made to pick up a load from an adjoining bay, return the arm with its load to a safe position under its own bridge, and carry the load along the runway without danger of striking any of the runway columns. An important feature of the crane is that when the extension arm is projected, the bridge cannot be traversed along the runway until the arm is drawn back to its safe position. This is accomplished by using the same motor for traversing the bridge and projecting the arm, and having special clutches to throw out one movement when the other is thrown in.

Among the men at the Camden yard the extension-arm cranes are commonly called "rubber necks." The seven and one-half-ton cranes are of 38 feet 4 inches span, and have a lift of 26 feet. The hoisting is accomplished by a 25-horse-power street railway motor, the trolley is traversed within the bridge by a $7\frac{1}{2}$-horse-power enclosed crane-type motor, and the bridge travel is performed by a similar machine, which, as already explained, is also arranged to operate the extension arm.

It was mainly in the adoption of electricity for the operation of all classes of machinery and tools on a more extensive scale than had ever before been attempted that the New York Shipbuilding Company especially departed from the practice of other yards. Instead of confining its electrical equipment to conventional lines, it extended its field so as to include practically every form of apparatus employed in the building of a modern ship. Shafting was almost completely eliminated throughout the works. A few of the smaller machines are grouped under the gallery in one end of the machine shop, and some in the joiner shop and tool room, and they are driven from shafting operated by motors, but these are exceptional cases, as will perhaps be better realized when it is stated that there are 312 separate motors employed in driving distinct machines. These motors range from 2 to 50 horse-power, and many of the applications are innovations in shipbuilding practice.

It is in the field formerly occupied by steam and hydraulic power that the electric motor has made its most distinct advancement. Hydraulic power often displaces steam power, because the power delivered by a steam engine is necessarily variable through each stroke, while that delivered by the hydraulic ram or press is constant within the limits of its useful range. The steam engine cylinder receives steam during only a portion of its stroke, and for the re-

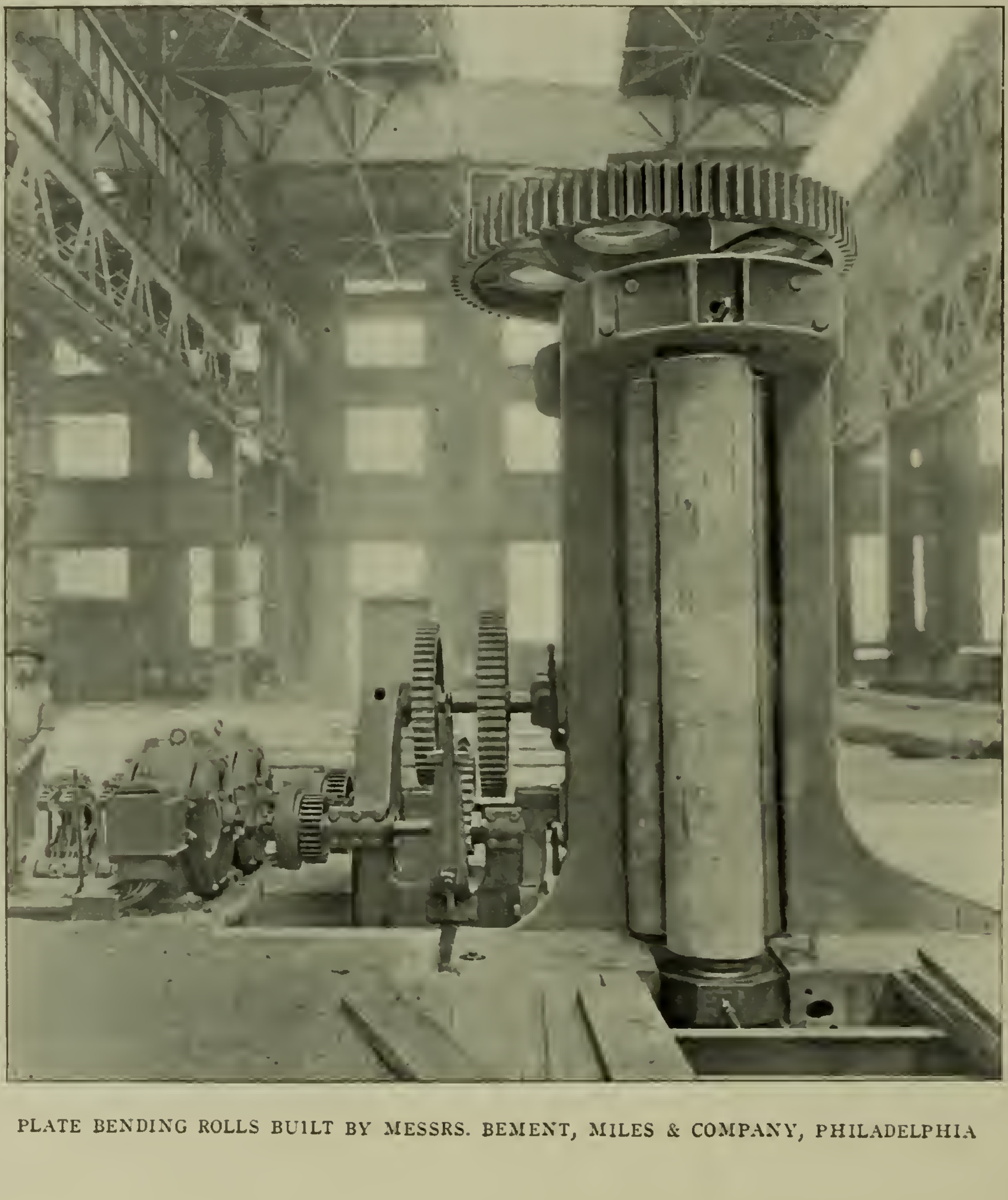


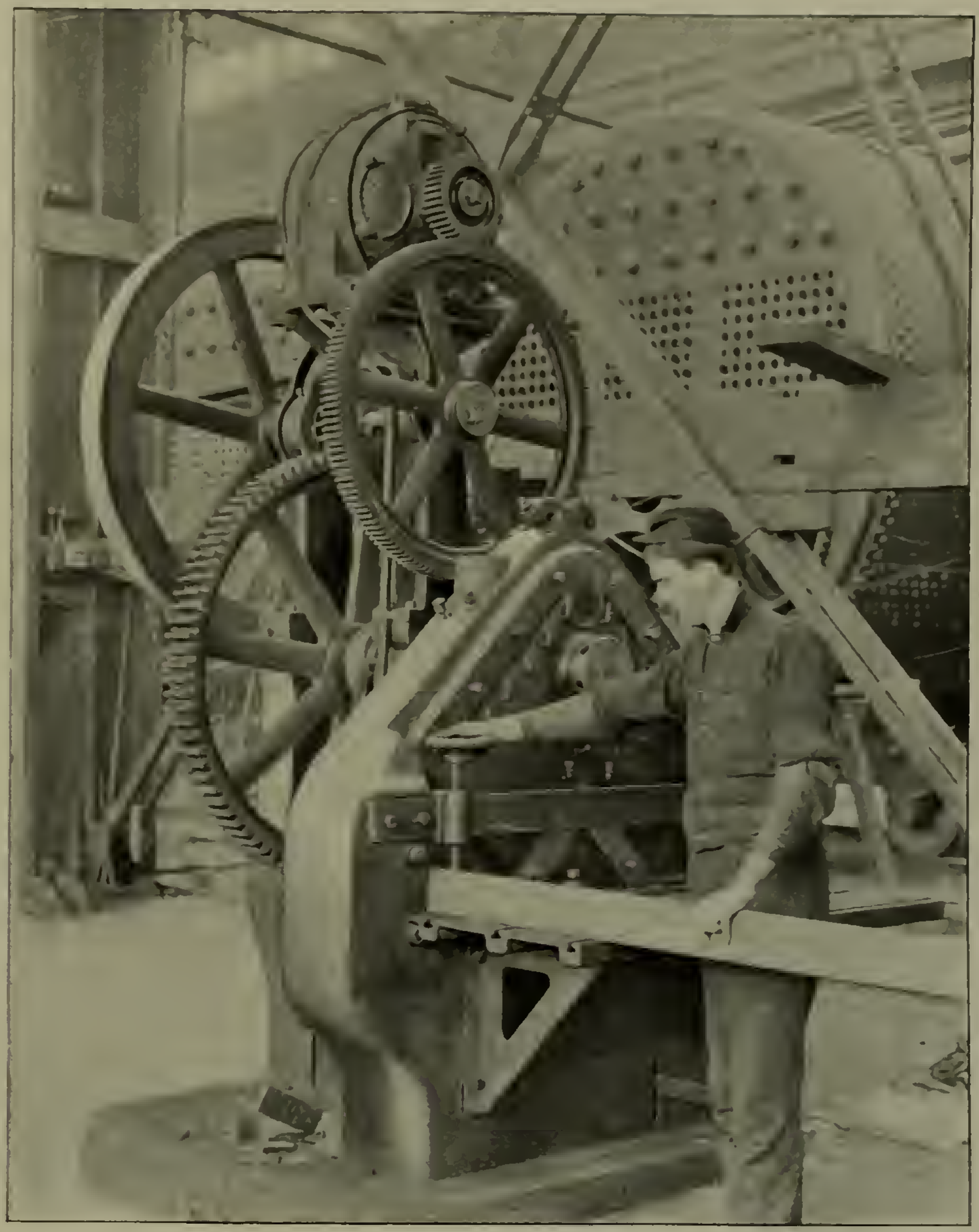
PLATE BENDING ROLLS BUILT BY MESSRS. BEMENT, MILES & COMPANY, PHILADELPHIA

mainder of the stroke the energy delivered to the piston is constantly falling. With the electric motor this variation does not exist, and when the supply service is properly arranged, the motor selected of proper size, and other conditions are favourable, the energy delivered by the electric motor is as uniform as that delivered by the hydraulic press, and all danger of the system being crippled on account of frost in the busiest time of the year is eliminated. A glance at the illustration on page 417 of the main bay of the machine shop and the boiler shop beyond will convince the observer of the wisdom displayed by the management in adopting electricity and eliminating shafting from these works. It leaves the space overhead clear for the operation of cranes, affords much better light and ventilation, and by using separate motors for each machine a more advantageous arrangement in every respect is secured. Tools may be placed wherever it is most convenient to handle the work for which they are intended, and the flexibility of the system renders it possible to transfer these tools from one part of the shop to another if necessary.

Throughout the plant Westinghouse polyphase induction motors have been adopted for operating machinery of every description and driving machinery tools. Some of these include more than one motor. Many of the larger machine tools, indeed, require two or three motors, as in the case of a boiler shell drill and a large boring mill.

The extent and variety of operations performed by these motors and the conditions under which they make the equipment an unusually interesting one. A few words about the general design of this type of motor and the features which commend it particularly for this work may be fittingly introduced here. There is no sliding or working friction except that of the shaft in the journals; and the only parts that can wear, therefore, are the shaft and journal boxes. The friction in these is very light, owing to the light weight of the rotating part and the ample bearing surfaces provided. Self-oiling bearings afford liberal lubrication.

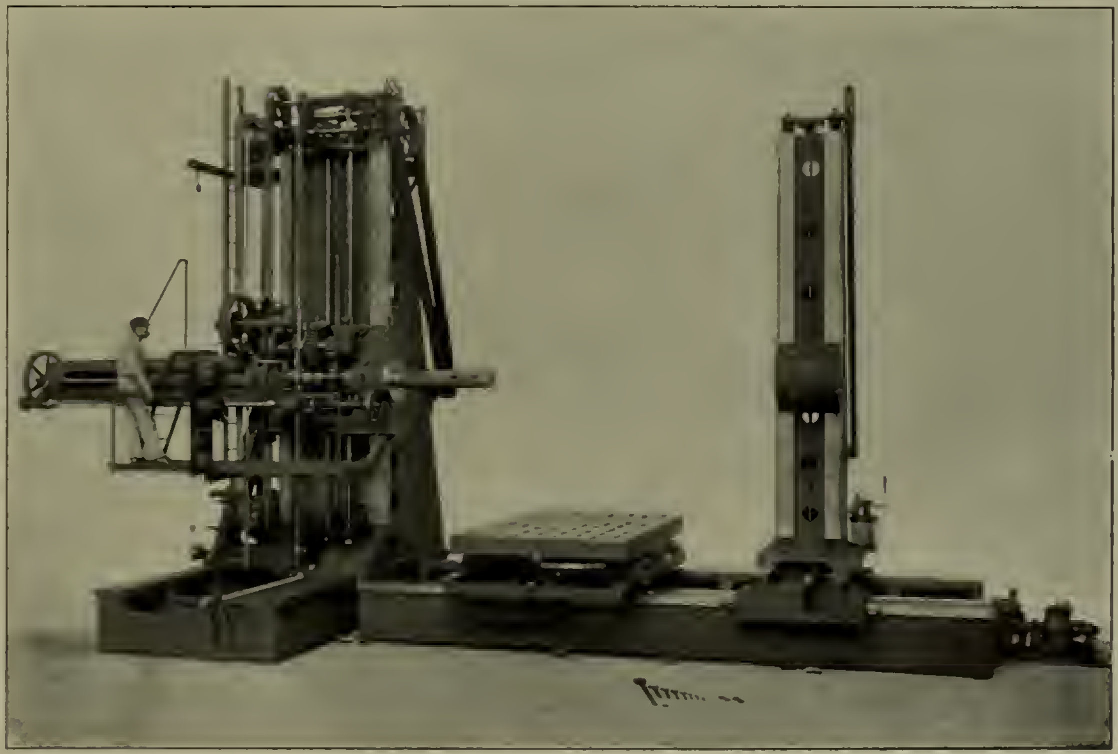
The motors may be suspended at any angle, and they may be put in out-of-the-way, almost inaccessible, places; in fact, they are often purposely put out of reach of workmen who are not familiar with their construction, but who, through curiosity, might "tinker" with them, and thus damage them. End brackets, which are parts of these motors, may be bolted to the frame in eight different



AN ANGLE SHEAR BUILT BY THE LONG & ALLSTATTER COMPANY, HAMILTON, OHIO

positions, and the oil chambers in the brackets will still be in the proper position whether the frame is bolted to the floor, the wall, the ceiling, or at an angle of forty-five degrees. The only attention and care required by these motors consist chiefly in an occasional renewal of oil; they are thus especially desirable for continuous service over long periods of time without expert attendance.

Motors of this type, in the sizes used in this plant, may be started by connecting them directly to the circuit with an ordinary switch, but

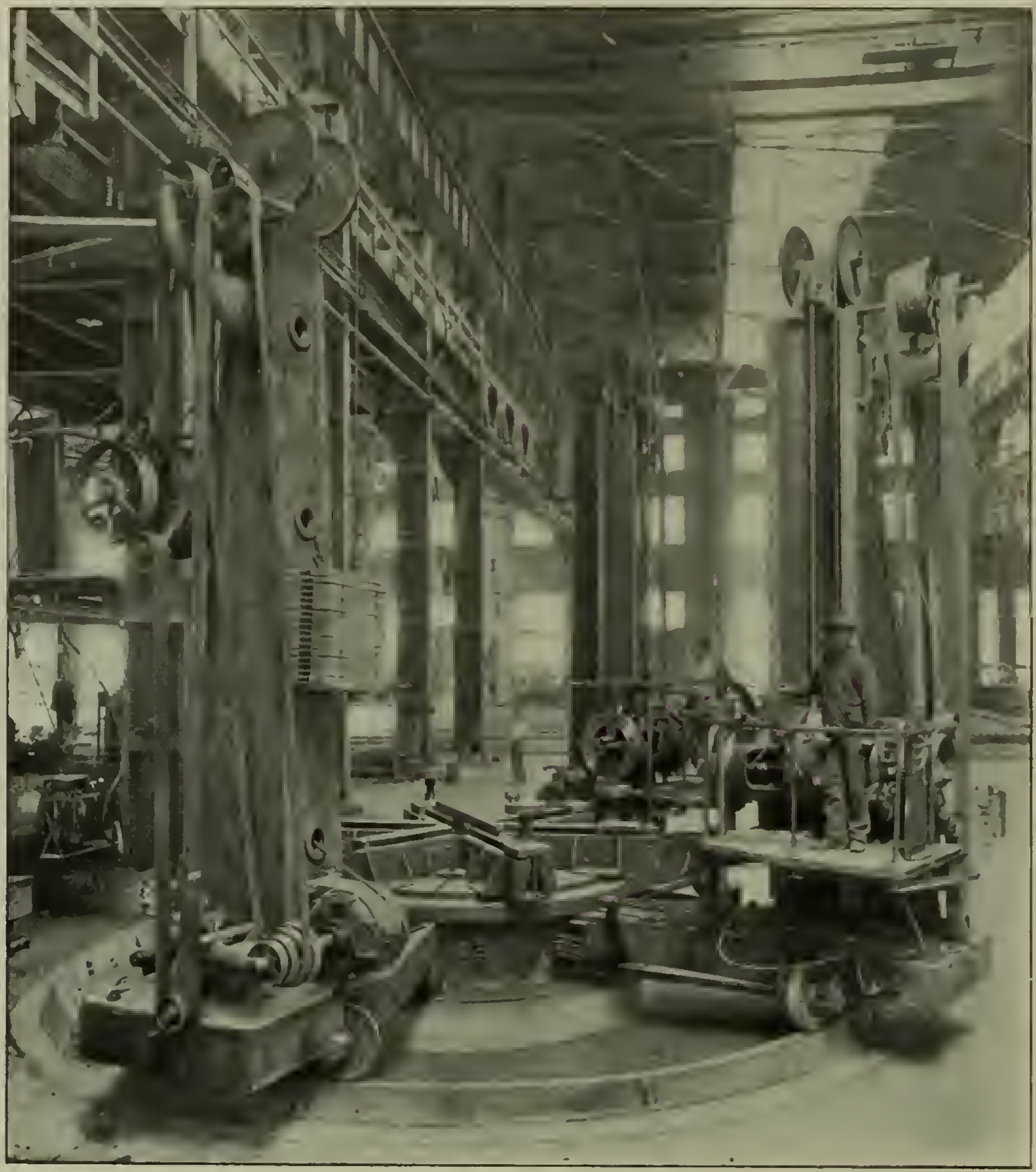


A BORING, MILLING, AND DRILLING MACHINE

the larger motors are generally started on reduced voltages by a special double-throw switch, the full electromotive force not being applied until the motors have attained their normal speed. The starting device may be remote from the motor, and this is often the case in places where there are inflammable gases, as well as when the motors are suspended from ceilings or installed in places not easily accessible, as in the installation under consideration.

It would be impossible within the limits of this article to describe in detail all of the applications in which these motors are employed, but a few of the more important and interesting combinations are illustrated, and they will serve as examples of their respective classes. The plate room contains several interesting applications. At one side is a flanging machine. The deck and bulkhead plates are taken from the laying-off tables to the joggling rolls, which bend the edges, so that wherever lapped they present plane surfaces. There is also in use in this part of the works a scarfing machine to plane off the plates to a feather edge. Beyond these are punches, shears, drills, and other tools. There are rotary shears and a 60-inch guillotine shear, on which a 50-horse-power motor has been installed to replace the steam engine with which it was originally equipped.

Two 30-foot planers are used for planing the calking edges of plates. Several small punches for brackets and intercostals are operated at the lower end of the shop; also a horizontal punch, and a combined punch and shears which can be used for cutting limber holes. There is also a notching machine and two 6-inch radial drills. At the lower end of the shed are two rolls, one of which can handle a plate 27 feet wide; the other is used for rolling mast plates.



MULTIPLE SPINDLE BOILER SHELL DRILLING MACHINE, BUILT BY THE NEW YORK SHIPBUILDING COMPANY FOR ITS OWN USE

In the angle shop, as in the plate room, the tools used are of the latest design for handling every class of work. Among them are channel and I-beam shears; two cold saws, one mounted on a turn-table for cutting at any angle; punches for punching straight beams; a portable punch and countersinking press and angle shears mounted on a turntable.

The main floor of the machine shop contains probably the largest and most complete equipment of tools of all sizes for this class of work to be found in any shipbuilding plant in the world. There are so many large machines on this floor that they lose the distinction they would have in smaller plants. Among the most notable are a 16-foot vertical boring mill fitted with three boring arms, two for use when the work is revolving and one when it is stationary; and a large drilling, boring, and milling machine with 8-inch spindle, equipped with steel scales and verniers for placing the work on the table and measuring it in each direction. There are two band-saws for cutting steel, such as eccentric straps, built by Messrs. Noble & Lund, Ltd., a British firm, of Newcastle. There are further a 72-inch open-side planer that will take a piece 28 feet wide; a 96-inch planer which will take work 36 feet wide; two double-headed lathes, one 48 inches and the other 63 inches, each 60 feet long, and a large array of other tools, each driven by its own motor.

There is a very complete electrical repair shop in the east gallery, equipped with lathes, planers, drill presses and small tools, such as are generally found in repair shops, all electrically driven. Another shop in the west gallery is thoroughly equipped with pipe-cutting and threading machines, lathes, drill presses, and grinding machines, all likewise driven by motors.

The boiler shop naturally contains many heavy tools. The plates are first rolled in the straightening machines, which are all operated by electric motors, and are then put through the several processes for which they have to be heated. The shell plates are put through a vertical ten-foot roll, capable of handling plates $1\frac{1}{2}$ inches thick. There is a 28-foot planing machine, and an elliptical and circular boring machine. The plates are finally mounted on a multiple vertical boiler shell drill, designed by Mr. Henry G. Morse and built in these shops. Among other tools in this shop are four 6-foot radial drills, two shears for trimming $1\frac{1}{2}$-inch plates, bending rolls, horizontal punches, and countersinking machines.

The joiner shop, a two-story structure, located on the water front, is a model plant in every respect. It is equipped throughout with saws of various kinds, mortising and drilling machines, matching machines and planers. Each machine is independently driven, except some of the smaller tools, which are driven in groups. On the second story are benches for the lighter class of work. At one end of the floor is a separate

room for grinding the saws and knives used in this shop.

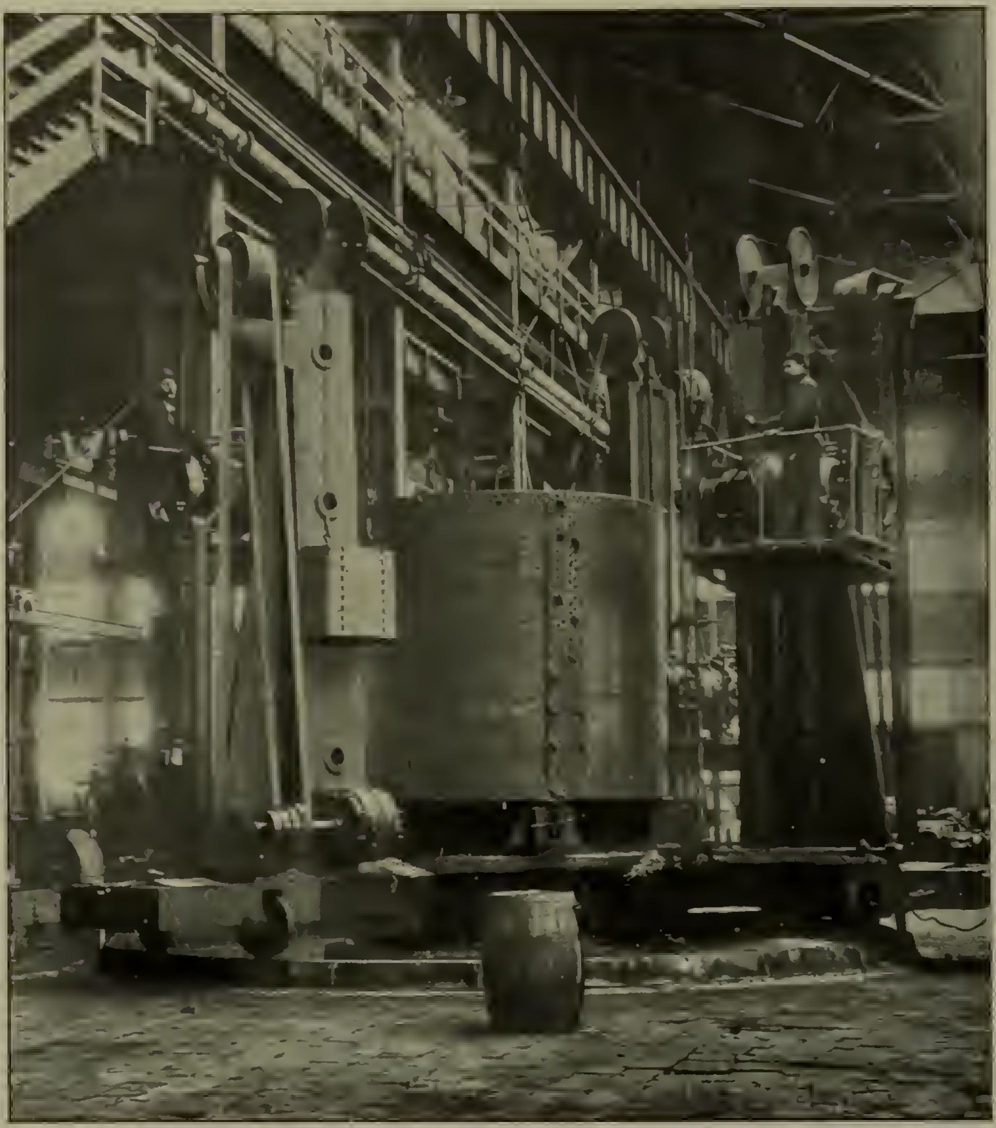
In selecting subjects for illustration among the machines installed in this plant the attempt was made to present types that would offer valuable suggestions to shop managers, as well as novel equipments designed to meet special conditions. These applications cover a wide field of operations, and may be studied with profit by managers of works of this class.

Plate-bending, straightening and flanging rolls form an important part of the equipment of every shipbuilding plant, and in this installation an excellent opportunity for utilizing electric motors directly connected, geared and belted to this class of tools was presented. One of the most conspicuous features of the boiler shop is an equipment comprising large, vertical plate-bending rolls, driven by two motors of 50 horse-power each. These rolls were built by Messrs. Bement, Miles & Co., of Philadelphia, and are capable of handling the largest boiler plates used in these shops.

The Hilles & Jones Company, of Wilmington, Del., furnished six horizontal roll equipments of various sizes, all motor-driven. One set of six 14-inch diameter plate-straightening rolls, 10 feet 2 inches between the housings, was designed for steam driving, but a motor was attached by the New York Shipbuilding Company, and the change has proved beneficial. Another set of the same general design is furnished with six 10-inch diameter rolls, 7 feet 2 inches between the housings. One set of plate-bending and flanging rolls, 27 feet 2 inches between the housings, with a top roll 27 inches in diameter, and the lower rolls each 20 inches in diameter, has a capacity equal to bending 1⅛-inch plates the full width, or flange ½-inch plates 20 feet wide. A 50-horse-power motor drives the lower rolls, which are geared by means of cast-steel pinions. The top roll is raised and lowered by a smaller motor placed underneath the lower rolls. Another set of plate-bending rolls, 7 feet 2 inches between housings, with top roll 8 inches in diameter and bottom rolls 6½ inches in diameter, is used for light work.

Several heavy plate planers are in service. These will plane plates 30 feet long at one setting, and any greater length by shifting the plate. Each machine is driven by a 20-horse-power motor attached at the end of the clamping beam. The motor is belted directly to the driving pulley on the machine, and special friction clutches are provided for reversing. A valuable feature of this equipment is that the machine may be reversed by the operator, or it may be set to reverse automatically at any point desired. The slide rest carries a turnover tool-holder for planing in both directions with the same tool. The tool-holder is also arranged to swivel for planing bevels, and has a vertical adjustment for planing high angles. The machine is provided with a series of pneumatic clamping jacks which may be operated all together, independently, or in groups, as desired.

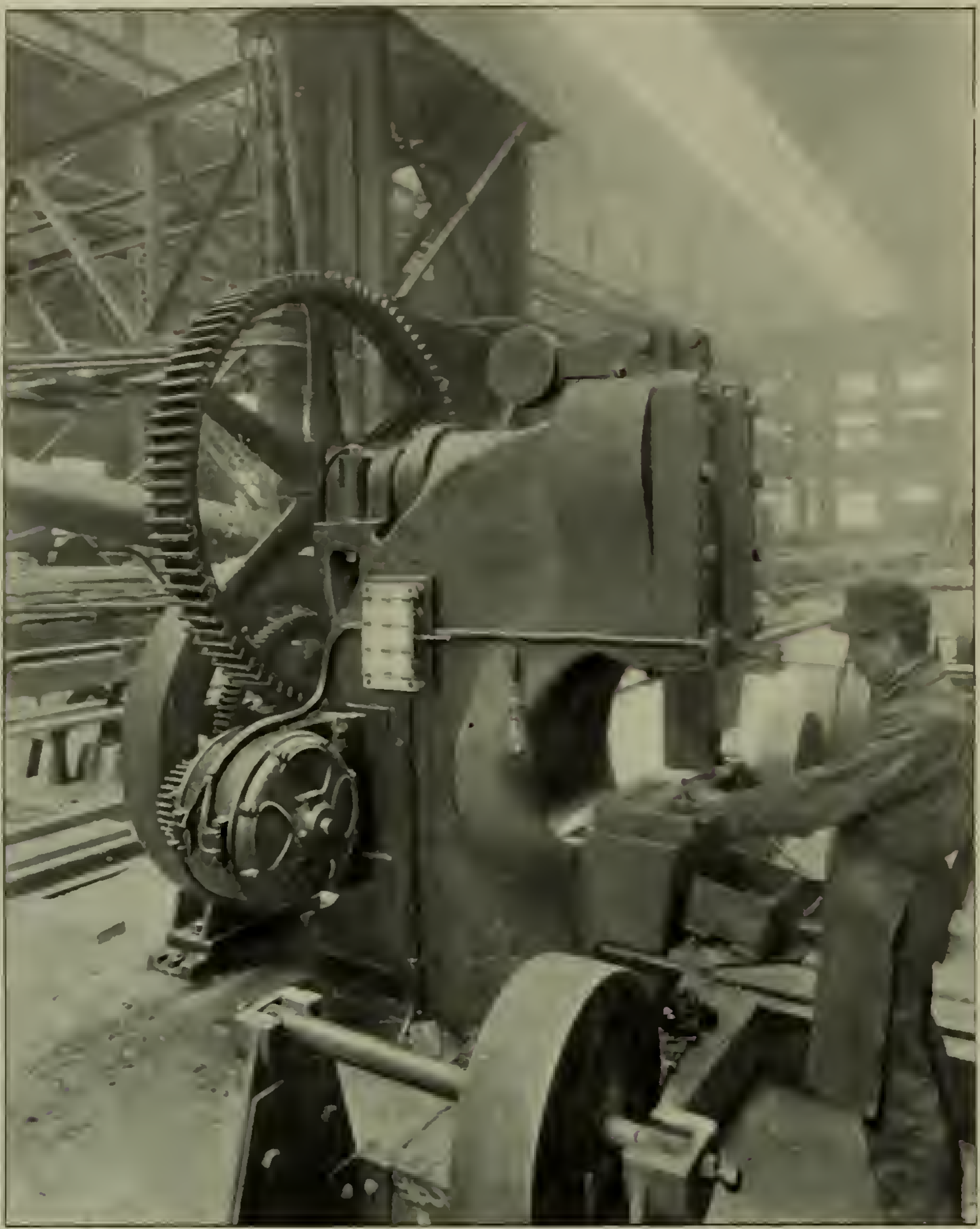
In an installation of this kind, as



ANOTHER VIEW OF THE MACHINE OPPOSITE, SHOWING A BOILER SHELL IN POSITION FOR DRILLING

A COMBINATION COLD SAW BUILT BY THE NEWTON MACHINE TOOL WORKS, PHILADELPHIA

might be expected, a large number and variety of punches are used. Several of these are operated by electric motors with satisfactory results. The Hilles & Jones Company have furnished one vertical and three horizontal punches, all electrically operated.



ONE OF THE MOTOR-DRIVEN PUNCHES

Of the horizontal punches two are of the type in which the punch stock is controlled by a hand gag, and the sliding head is running at all times when the motor is in operation. The throat depth is 11½ inches, and the tool has a capacity equal to punching 1¼-inch holes through material 1⅛ inches in thickness.

The other horizontal punch has a 11½-inch throat, and a capacity equal to punching a 1 1-16-inch hole in a 1-inch plate. Driving this punch is a motor with its pinion keyed directly to the eccentric shaft. The same company also furnished a rapid-action punch, with 30-inch throat, arranged for belt-driving directly on the fly-wheel. These machines are operated at a speed of sixty strokes per minute. They are provided with an automatic clutch for starting and stopping the sliding head, and this clutch is operated by a foot lever, bringing the punch under perfect control, in spite of the high speed at which it is operated.

Another interesting application of electric power is found in a 100-ton punch which was built by the New York Shipbuilding Company. It is driven by a 5-horse-power motor. This machine illustrates the possibilities of electric motors operating heavy tools when properly designed, and belongs to a class of apparatus formerly considered entirely out of the electrical field; but by utilizing the momentum of the fly-wheel in this combination a comparatively small motor does the work in a most satisfactory manner.

In the line of shearing and notching machines, an excellent example of motor-driving is illustrated on this page. These machines are designed to shear right and left-hand angles, to cut them off square, or at any angle up to forty-five degrees. When mounted on turn-tables, as in the present case, these machines can be turned around from side to side and made to face in any direction to avoid handling and turning the bars. The machine shown will shear 6 by 6 by 1 inch, right or left-hand angles; it is double-geared, mounted on a turn-table, driven by an electric motor, and is also provided with a friction clutch so that the motor can be run up to full speed before starting the machine.

Universal shears or plate-splitting and cross-cutting shears, with capacity to cut 1-inch plate, are used for cutting plates, angles and bars. The lower blade is adjustable to and from the upper blade, so as to make the proper allowance for different thicknesses of material to be cut.

An interesting combination is found in the machines for cutting notches, 4 inches by 6½ inches, in channels. These tools are turreted, so that they can be revolved, and a notch can thus be cut at any angle, without changing the position of the work. These shearing and notching machines were built by the Long & Allstatter Company, of Hamilton, Ohio, who also furnished a smaller angle-iron shear equipment and a large motor-driven punching machine.

Probably the most interesting machine in the boiler shop is the four-spindle boiler-shell drill previously referred to and shown on pages 422 and 423. This machine has three columns, each of which has a saddle with four drill spindles arranged so that three drills on each saddle can be placed in either a horizontal or vertical plane. This machine will handle boilers up to 20 feet diameter, and 20 feet length. The details of the machine and the application are shown in the illustrations, one view representing a boiler secured in place. About it are three drill heads, each containing four spindles, which can be operated at the same time. They are adjustable in all directions. Twelve holes can thus be drilled radially at the same time, and then the drill heads can be shifted to drill twelve more holes about the periphery. Three 10-horse-power motors are employed on this machine.

The largest lathes in the shop are two of the double-head type, made by Messrs. Bement, Miles & Co., one 48 inches by 60 feet, and the other 63 inches by 60 feet. They are capable of handling the largest pieces of work in these shops. Several motors are used on each of these tools, one having a 7½ horse-power and a 10 horse-power, and the other requiring one 5 horse-power, one 10 horse-power, and one 20 horse-power. The motors are mounted on adjustable brackets attached to headstocks and belted to cones on the machines for obtaining speed variations. Power

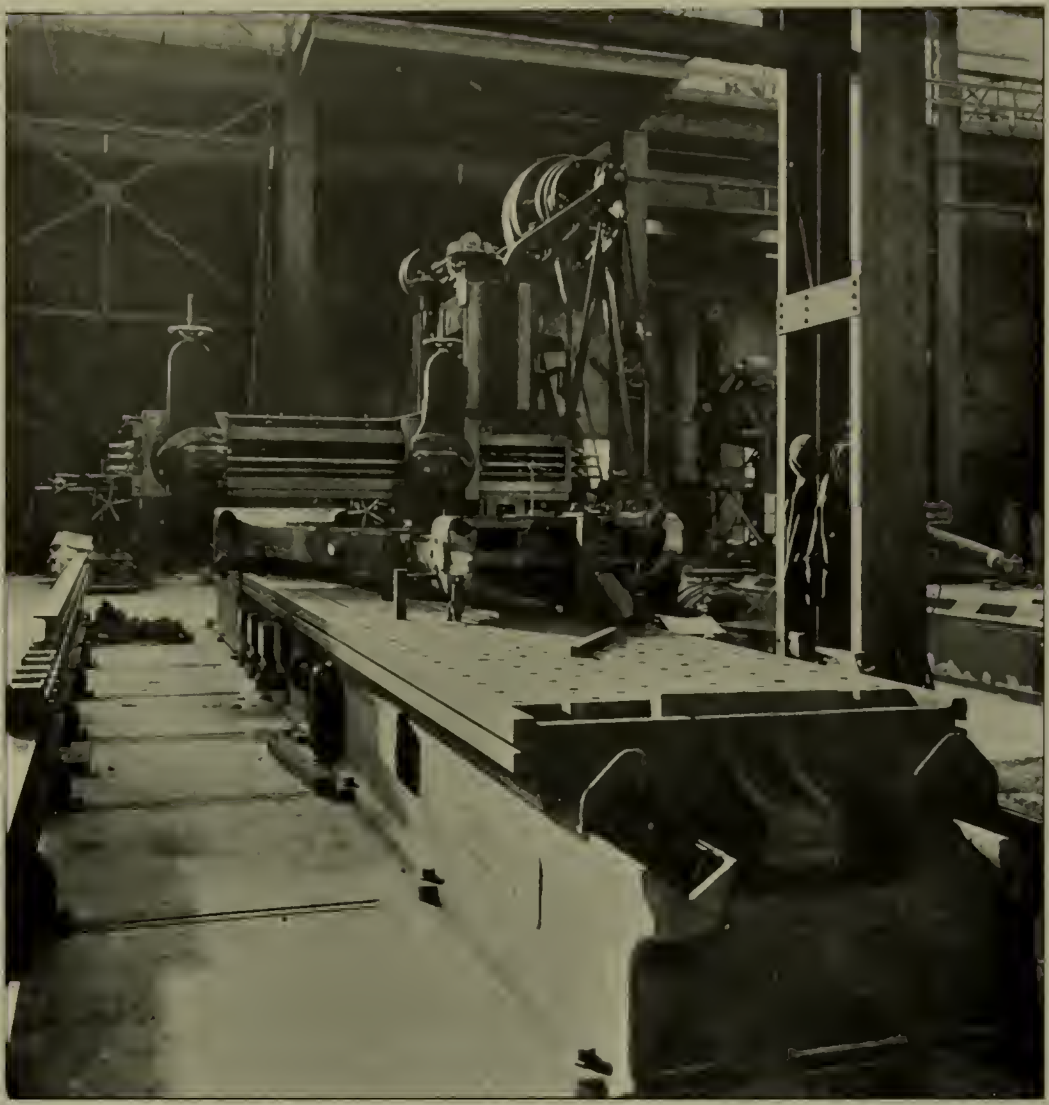
traverse by motor is provided for the carriages on the lathes.

Two types of cold-saw cutting-off machines are employed—one for cutting bars and the other especially adapted for I-beams. The combination cold-saw shown on page 423 is an interesting application. It comprises a saw 26 inches in diameter, and has a capacity on top of the table 7 inches by 24 inches, and for I-beams on a square of mitre cut on the bottom table, 15 inches. The machine is driven by a direct-coupled $7\frac{1}{2}$-horse-power motor, and is revolved on the round bed by means of a small motor. The bar cold-saw cutting-off machine employs a 24-inch saw, and has a capacity for 7-inch round bars and 6-inch square bars. A $7\frac{1}{2}$-horse-power motor furnishes power for driving this machine.

Among the larger tools that attract special attention is a 72-inch open-side planer made by the Detrick & Harvey Machine Company, of Baltimore, Md. It is the largest tool of this pattern that has ever been made. It is designed to plane a surface 72 inches wide, 72 inches high, and 28 feet long, and it will take under the beam a piece of work slightly larger than the vertical dimensions given. The supplemental rolling table with which this machine is equipped is a very valuable attachment when large pieces are handled. It is shown at the side in the illustration on this page. When in use, this table moves simultaneously with the planer platen, and requires very little additional power. It forms the outer support for wide and heavy work, and for long pieces when planing off the ends.

A 96-inch planing machine, 36 feet long, weighing 174,000 pounds, belt-driven from an electric motor, was built by the Betts Machine Company from special plans of the New York Shipbuilding Company for this plant. A 30-horse-power motor furnishes power for this tool.

The boring mill shown on page 426 swings 16 feet in diameter, and takes 90 inches under the tools, permitting the bar to travel 48 inches. The tool is fitted with three boring arms, two for use when the work is revolving, and one for use when the work is stationary. The rim of the table runs in a groove cut in the bed and flooded with oil. The table spindle is very long and has a taper bush at the top for taking up wear; the lower step runs in oil, and is supported by a heavy conical casting extending down from the bed. There is a wedge with screw adjustment for raising the table slightly off the annular bearing when at high speed. The driving cone is large and strongly back-geared, giving ample power. It is placed at the left side within easy reach of the operator. The feeds are driven by a large, high-speed friction disk, which allows instant adjustment throughout its range while running. The gearing at the end of the rail gives an additional range of feed and allows the independent reversal of all the feeds, by

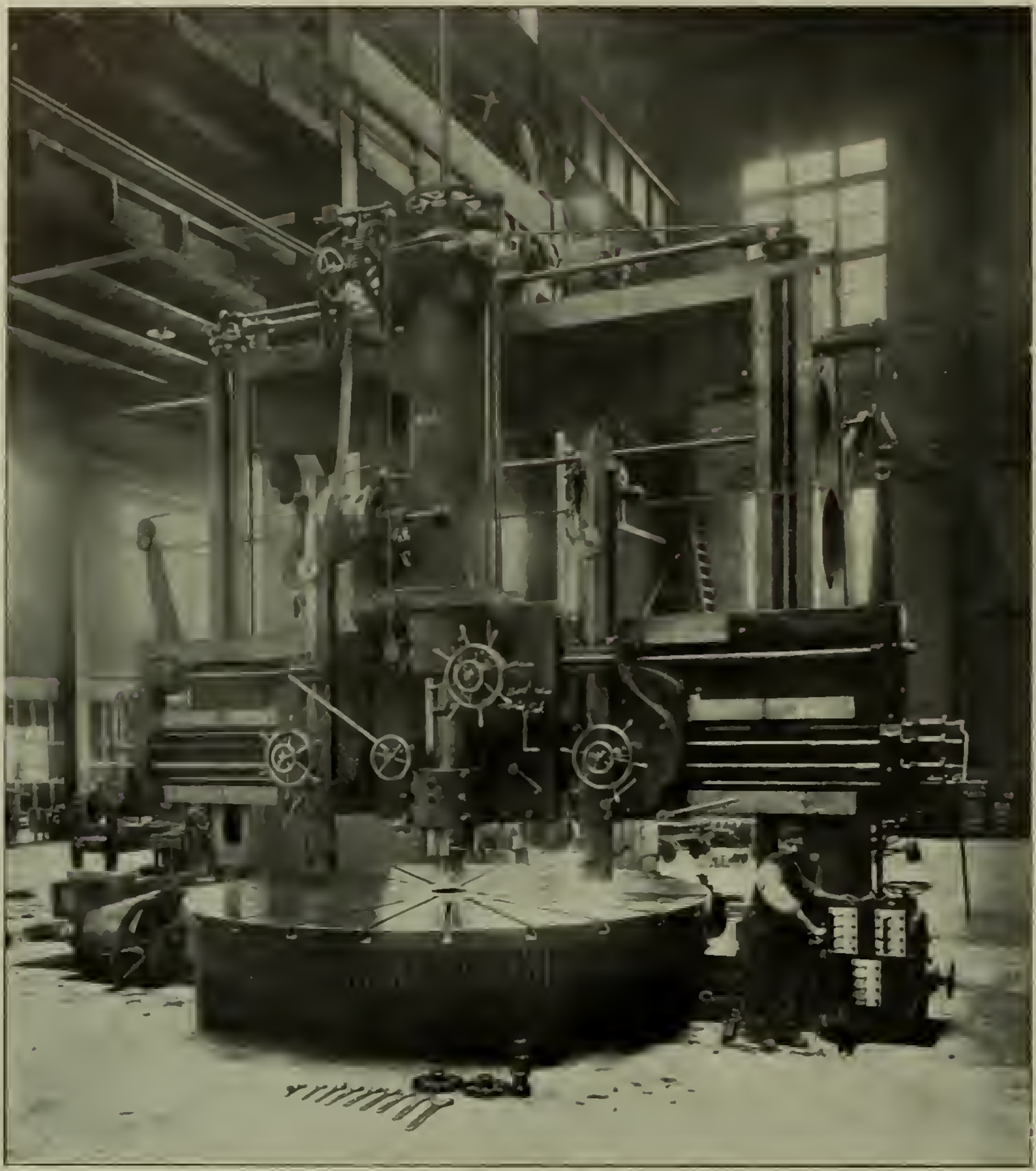


A HEAVY OPEN SIDE PLANER BUILT BY THE DETRICK & HARVEY MACHINE COMPANY, BALTIMORE, MD.

A RADIAL DRILL BUILT BY THE POND MACHINE TOOL COMPANY, PLAINFIELD, N. J.

sliding the slip gears on the rods and screws. Three motors are employed in operating this machine. They are of 3, 5, and 10-horse-power capacity, respectively.

The Niles Tool Works Company, who built this machine, also furnished several smaller tools of the same general class, including a 51-inch and an 8-foot boring and turning mill. Another equipment furnished by the same company is a heavy 18-inch shaping machine.



A 16-FOOT BORING MILL BUILT BY THE NILES TOOL WORKS COMPANY, HAMILTON, OHIO

The 6-foot radial drill shown on page 425 is belt-driven, a 3-horse-power motor being placed at the base of the machine. The traverse of the saddle on the swinging arm, and of the spindle, which is counter-balanced, is by means of rack and pinion so placed that workmen can operate both and swing the arm at the same time to bring the drill to the work. The belt is applied to a pulley locked to the spindle. The back gears are arranged the same as on a lathe and are as readily thrown in or out. Thus, for ordinary drilling, the smooth motion given by a belt is obtained, and for heavy drilling the power obtained by the use of back gears is applied directly to the spindle, in place of being transmitted through shafts and several pairs of bevel gears. The machine was built by the Pond Machine Tool Works, of Plainfield, N. J.

Two drills of the horizontal type, capable of drilling at any angle, boring, and milling, and provided with universal tables, were furnished by the Detrick & Harvey Machine Company, for handling general machine work. These machines are capable of performing nine distinct operations with one chucking, and are said to be as efficient and satisfactory in each of these as separate tools would be. Each machine consists of a bed-plate, on the main portion of which is fitted a column with a traverse of 40 inches or more if desired. It may be arranged for drilling and boring only, the column having a hand and quick power movement, but automatic feeds may be attached for milling when required. To the other portion of the bed-plate is fitted the universal table, which is very strong and capable of handling work of several tons. This table has a sliding movement of 30 inches to and from the column, being operated by a rack and pinion. The top, which is 48 inches by 36 inches, has a pivoted movement from a horizontal to a vertical plane, and can be rigidly clamped at any angle. It also has a rotary movement, which makes it possible to drill holes in any part of a hemisphere or in five sides of a cube without re-chucking the work. When extra large work is being machined the table can be lifted off the bed-plate. When used for boring, an outside support for the bar is furnished, which can be used either with or without the universal table. Power is furnished by a motor at the base of the machine, one tool requiring 5 horse-power and the other 3 horse-power.

The boring, drilling and milling machine shown on page 421 has a spindle 8 inches in diameter. The boring head carrying this spindle has a vertical travel upon the upright of 10 feet, and the main upright has a horizontal travel along its bed of 22 feet. All movements are made by power controlled by the operator when standing on the platform attached to the boring head. The platform travels with the boring head, so that the operator is in the same relative position to the boring head at all times. The machine is driven by a 10-horse-power motor, with a special service switch to vary the speed. A heavy outboard support is also provided, the bearing of which has a vertical adjustment, corresponding to the vertical adjustment of the main spindle. The adjustment of the bearing is made by a 2-horse-power motor. There is an adjustable work-table upon the cross bed which carries the outboard support. This is operated by a $3\frac{1}{2}$-horse-power motor.

Another tool worth noting is a special duplex milling machine, built by the Newton Machine Tool Works, of Philadelphia, driven by a 10-horse-power motor. This machine is provided with two heads, carrying spindles 5 inches in diameter. The maximum distance between the ends of the spindles is 42 inches, and the minimum distance $9\frac{1}{2}$ inches.

In addition to the separate motor-driven machine equipments mentioned, electric motors are used throughout the works for many other purposes, such, for instance, as operating the heating, ventilating, and blowing systems. In the power house a 5-horse-power motor is connected with a Green economiser, and a 40-horse-power motor drives the exciter for the generators. Two and five-horse-power motors operate ventilators. The shavings exhaust system in the joiner shop is operated by two motors, one of 30 horse-power

and one of 50 horse-power, and one 20 and one 30-horse-power equipment are installed for the blower system. Shafting in the machine shop and the joiner shop is driven by motors of 5, 7½, 10, 15, and 20-horse-power capacity.

The ultimate point to which all these operations are directed is the completed ship, and this, like everything else about the plant, remains under cover until it is entirely finished, furnished, tested and ready to start into service. The assembling of parts and installation of machinery are completed on the ways and outfitting slips, and this department of the plant is the destination of every bolt and nut, every bar and plate that comes into the shop to be handled, formed or finished by the machinery and appliances already described.

The launching ways are at the end of the plate and frame shops, and are directly opposite the machine shop. The height of this portion of the building above the water is 125 feet, and the depth of the water in the slip is 30 feet at low tide. Eight launching ways have been constructed and each will accommodate a ship 650 feet long. A 100-ton crane travels over all the launching ways and the outfitting slip. It can pick up a completed engine or a boiler weighing 100 tons and deliver it on board a ship on any of the ways or in the slip. The lighter engines will be transferred bodily; those weighing more than 100 tons will be partly dismantled for removal to the ship. Two cranes of ten tons each and one crane of five tons travel over each of the launching ways and the outfitting ship.

Taking everything into consideration, the plant may be considered a model installation.

One type of electric furnace for the production of glass is that in which the heating material is powdered carbon or "Kryptol." The material to be fused is placed in a vessel and surrounded by the powdered carbon. A very high current density is employed, which must be regulated by a rheostat, a pressure of about 100 volts being used. The electrodes are carbon rods, one at the bottom of the vessel and the other forced down into the loose material from the top. By means of triangular strips of carbon placed in contact with the vessel to concentrate the current at certain parts, the glass may be fused at temperatures lower than that of the arc furnace.

Up-to-Date Methods of Getting New Business

THE Kokomo, Marion & Western Traction Company, of Kokomo, Ind., carries at one station the electric lighting load of Kokomo and Swayzee and also operates the street railway system in Kokomo and the interurban railway between Kokomo and Marion. T. C. McReynolds, secretary and treasurer of the company, believes that pushing the central station end of the business will result in greater revenue than would be the case were the traction end chiefly considered.

Sixty-cycle, three-phase current is generated at 2300 volts, that pressure being used for distribution in Kokomo, but raised to 10,000 volts for transmission to the sub-station at Swayzee, where it is stepped down and used for supplying the interurban railway and for lighting at 208 volts on the three-wire system.

All along the line between the Swayzee sub-station and the Kokomo power house, where the demand is sufficient to justify it, a transformer is installed and the current stepped down to the voltage suitable for lighting and power purposes.

Until this year, not much effort was made toward the introduction of electric current for use in the home, except for lighting purposes. However, the company had been experimenting with different cooking and heating devices for some time. On March 1, Mrs. F. Violet Sanborn was employed to give a course of illustrated lectures relative to the various uses to which electricity can be applied for household and domestic purposes.

These lectures were given in a hall, lasting two hours every afternoon for a week. In connection with the lectures, demonstrations were given, various kinds of dishes were prepared, accurate account being kept of the current consumed, and the audience was informed as to just what it would cost to prepare different articles of food ready for the table. This created quite an interest, and the hall was crowded with ladies every afternoon.

Cooking apparatus of various kinds were kept on exhibition in the hall, including a coffee percolator, chafing dish, electric ovens, water heater, smoothing irons, motors for sewing machines, and the like. Immediately after the lectures, the audience was invited to inspect the apparatus, and the company's solicitor had an opportunity to get in touch with prospective customers.

Immediately after the course of lectures had ended, solicitors were sent out, and they left flat-irons and cooking devices on trial. As a result more than 100 flat-irons were placed during March and April, and 75 more were secured which it was expected to put out within the next thirty days. Three complete cooking outfits were also sold.

Current is sold for cooking and heating at 5 cents per kilowatt, covering a minimum charge of $3, and all over that is 3½ cents per kilowatt. Where smoothing irons only are used in the residence, no reduction is made.

It is believed that more can be accomplished in the immediate introduction of electricity to its various uses in the home, by a week's lectures from some one competent in that line, than by several months' effort from a solicitor. However, the lectures would be of little value if the customers were not followed up by a solicitor. Some advertising is done in the local newspapers, but not as much as there ought to be. Mr. McReynolds says that, in his opinion, every family able to have electric lights can be induced to buy an electric smoothing iron.

Kokomo has a population of 16,000 people. There are now connected 800 consumers; a year ago 485 consumers were connected. At present 800 meters are installed, and a year ago there were 466 meters. The company have now connected 14,000 incandescent lights, and a year ago there were 8000. A commercial power load of 400 horse-power is carried now, whereas a year ago the motor load was 40 horse-power. Of heating devices connected up, flat-irons number 100, and there are several individual cooking units; a year ago there were none. It is expected that just as much of an advancement will be made in Kokomo the coming year as last year. The connections so far have averaged over 40 a month for all purposes.

The records of the performance to date of mercury lamps installed in 1904 and 1905, have demonstrated that the operating life of Cooper Hewitt tubes exceeds 5000 hours in numerous instances. The New York Transportation Company recently renewed four tubes which had been operated over 10,000 hours each, and three of them were in fair operating condition when returned to the factory, but somewhat blackened from long service.

An Analysis of Central Station Results in Massachusetts

By H. S. KNOWLTON

ONE of the most hopeful features of central station practice at the present time is the widespread interest apparent in the commercial side of the business. While it is true that the final object of the central station manager has always been the making of money for the investors in the company, it is also true that only within the last two or three years has the importance of coordinating the engineering and commercial branches of the work been generally appreciated.

Central station equipment has passed through a remarkable evolution in the last two decades, and important developments are still afoot in the power plant and distributing system. Apparatus has now become so reliable, in the main, that the central station manager has more time to consider the broader problems of his work than in the days when the probability of a breakdown in the service supply was ever present, and other conditions have arisen which demand attention with even more insistence than the physical plant.

The day seems to have passed when a central station manager can increase his business in large degree by simply waiting for customers to come to his office or by making haphazard attempts to add to his connected load. Gas competition was probably never more severe than at the present day, isolated plants continue to be built, and the questioning attitude of public sentiment toward electric light and power companies has developed to a point where it has to be long and carefully considered in every important change of a company's policy.

Organized methods of securing new business are, therefore, very much in vogue, and the broad questions of policy in relation to the public's points of view are receiving the most earnest and sympathetic thought from central station executives. Along with the new life which has been infused into the commercial departments, has come a more scientific interest in the production economy of the entire physical plant. No apologies are, therefore, needed for the presentation here of some of the financial results of operation of the more important central stations of Massachusetts, as deduced from the recently published Twenty-first Annual Report of the Board of Gas and Electric Light Commissioners, covering the fiscal year ending June 30, 1905, and the calendar year 1905 itself.

The eighty-three central stations of the State, not including municipal plants, earned in the fiscal year under consideration, $8,108,265.73. More than $3,346,000 of this sum were earned by the Edison Electric Illuminating Company, of Boston. By reducing all the receipts and expenses of these stations to the basis of each dollar earned, a good idea can be obtained of the relative cost and revenue items of the central stations operating in Massachusetts. Table I. shows the distribution of revenue:—

TABLE I.

Sale of commercial arc lights by contract	$0.022
" " incandescent lights by contract	.023
" " " and arc lights by meter	.551
" public arc lights	.182
" " incandescent lights	.051
" electric power	.156
" current to other companies	.011
Rent of motors, fixtures and meters	002
Sale of steam heat	.002
Total	$1.000

Two points in the above table are of special significance. One is the very large sale of current by meter instead of by contract rates, and the other is the promising outlook for sales of power. There is room for great expansion in the latter direction. It is scarcely to be expected that the income from power sales will approach closely to the lighting income for some years, but less than 16 per cent. of total earnings is a small proportion in view of the possibilities. Actually, the sales of power increased about $59,000 over the preceding year, and, as we shall see later, active efforts have been made in central station circles to increase the motor load.

Massachusetts is a great manufacturing State; thousands of horse-power are supplied by steam engines scattered about in factory installations with all the losses and burdens of the belt and shafting drive; coal is far from cheap; it ought, then, to be a good field for the central station man who is alive to the possibilities of motor applications in increasing his day load. One would scarcely expect that the income from public arc lighting would exceed the power income, but such is the case at present.

From this table it would appear that the great majority of the consumers of central station energy in Massachusetts own their motors and fixtures. The sale of steam heat has evidently been but little practiced in comparison with other sources of income. The amount of electric heating cannot be determined, as this apparatus is often operated at the regular lighting rates, upon incandescent circuits. The adoption of the meter rate in place of the contract rate is thoroughly in harmony with the tendency of good practice.

Eight companies supply power to a connected motor load, in each case, of 1000 H. P. or over. Table II. shows the horse-power of motors supplied at the time of the returns:—

TABLE II

Company	Motor H. P.	Tributary Populat'n per H.P.
Edison Elec. Illtg. Co., Boston	26,416	27
Lowell Elec. Lt. Corp	3,446	31
United Elec. Lt. Co., Springfield	3,345	26
Haverhill Elec. Co.	1,657	24
Cambridge Elec. Lt. Co.	1,640	59
Lynn Gas & Elec. Co.	1,480	60
Lawrence Gas Co.	1,142	79
Worcester Elec. Lt. Co.	1,126	114

The last column of Table II. is an attempt to obtain a figure for these companies which will give an idea of the extent to which power is used in the territory served in proportion to the population. It is certainly remarkable that in the comparatively small city of Haverhill there should be 1 H. P. of connected motor load to 24 people. Doubtless reasons affected by local considerations could be advanced to account for the wide differences here noted, were one intimately acquainted with the situation in all the cities.

The amount of manufacturing carried on in any given city would naturally have quite a substantial bearing upon the demand for power, as would the presence of a large natural water power, as in Lawrence. The low "power saturation" of Worcester,—a large manufacturing city depending upon steam power alto-

gether,—would seem to indicate possibilities in the way of motor load development. The manufacturing city of Lynn offers good apparent opportunities in this respect also.

Haverhill, Springfield, Boston, and Lowell show the greatest motor horse-power density in proportion to inhabitants. Cambridge is very largely a residential suburban city, so that a very general use of power could not be expected there on this basis. A few very large consumers might easily turn the balance up or down in weighing the relative power use of any community, but outside of Boston there are comparatively few very large power customers of Massachusetts central stations, such as one finds in the Niagara and various Western localities. There long and short-distance hydro-electric transmission, at high economy of operation, is in effect. It is interesting to record the fact that an increase of 43 per cent. in connected motor load was made in Springfield during 1905, in comparison with the preceding year.

The operating expenses of the eighty-three stations, on the basis of each dollar earned, are shown in Table III.

TABLE III.

Coal or other fuel	$0.122
Rent of real estate used for plant	.012
Oil and waste	.004
Water	.006
Wages at station	.072
Station repairs	.004
Steam plant repairs	.015
Electric plant repairs	.011
Apparatus and machinery	.007
Wages for care of lights and meters. clerical labour in this department, and salary or commission of collectors	.031
Repairs and renewals of lines, meters, lamps and motors	.067
Distribution tools and appliances	.005
Carbons	.009
Incandescent lamps	.021
Globes	.001
Directors' allowances	.002
Salaries of officers	.022
General salaries	.034
Rent of offices separate from plant	.003
General office expenses	.025
Taxes	.074
Insurance	.016
Legal expenses	.007
Claims	.002
Bad debts	.004
Incidental expenses	.002
Current purchased	.011
	$0.589

The notable features of this table are many. Perhaps the most prominent point is the variety of expenditures and their relative similarity in magnitude. With the exception of the fuel account, no single item exceeds 8 per cent. of the total receipts. Fuel, station wages, repairs and renewals of lines, meters, lamps and motors, and taxes, are the most prominent items. It is interesting to note that lines, meters, lamps and motors require over twice the expenditure for repairs that the electric plants, steam plants and stations do. Salaries and wages do not form a very large total, in comparison with the transportation industry and certain manufacturing work, such as the production of shoes, watches, etc.

The comparative insignificance of the item of carbon expenses must, in part at least, be due to the increasing use of enclosed arc lamps. Incandescent lamp renewals are an item of note, in comparison with many of the other expenses. Legal expenses are most agreeably small, in comparison with the experience of some of the larger street railway companies.

It must not be concluded that an item in Table III. is unimportant because its percentage relationship to gross earnings is not high. Thus, distribution tools and appliances amount to but one-half cent upon each dollar earned, but in toto the expenditure for these appliances comes to over $43,000. The lesson of Table III., then, is that it is worth while to attempt a reasonable saving in any one of the items of central station expense, that only a few items are of excessive importance from a comparative standpoint.

From each dollar earned, the apparent net profit is, therefore, 41.1 cents. Of this profit, the gas companies made in their electrical departments 7.8 cents, leaving for the electric light companies 33.3 cents, to which should be added 2.8 cents as income from rents, jobbing, etc., making a total of 36.1 cents. Interest charges came to 4.6 cents, dividends to 18.3 cents, and depreciation to 3.8 cents, the balance of 9.4 cents being devoted to sundry items, which required 0.9 cent in addition.

The gross earnings per capita for each community of 10 000 population or over are given in Table IV.

TABLE IV

Company	Tributary Population 1905	Gross Earnings per Capita
Edison Elec. Ill. Co., Boston	722,089	$4.64
Worcester Elec. Lt. Co	128,135	2.28
Lowell Elec. Lt. Corp	106,401	2.32
Fall River Elec. Lt. Co	105,762	1.94
Malden Elec. Co	101,129	1.99
Cambridge Elec. Lt. Co	97,434	2.40
Lawrence Gas Co	89,272	1.72
Lynn Gas & Elec. Co	89,358	2.94
United Elec. Lt. Co., Springfield	86,486	3.96
New Bedford Gas & Elec. Lt. Co.	78,597	1.66
Edison Elec. Ill. Co., Brockton	54,315	2.42
Newton & Watertown Gas Lt. Co.	48,085	2.14
Boston Con. Gas Co., B'kline, Bos.	45,242	4.53
Haverhill Elec. Co	40,231	2.28
Charlestown Gas & Elec. Co	39,983	1.48
Salem Elec. Ltg. Co	37,627	3.68
Chelsea Gas Lt. Co	37,289	2.29
Fitchburg Gas & Elec. Co	33,021	2.72
Gloucester Elec. Co	30,458	2.26
Pittsfield Elec. Co	28,123	3.96
Quincy Elec. Lt. & Pr. Co	28,076	2.44
Waltham Gas Lt. Co	26,282	3.82
No. Adams Gas Lt. Co	23,350	3.90
Northampton Elec. Ltg. Co	19,957	2.62
Sub'n Gas & Elec. Co., Revere	19,693	4.56
Central Mass. Elec. Co	17,783	2.37
Webster Elec. Co	16,763	1.44
Beverly Gas & Elec. Co	16,147	3.65
Waldon Elec. Co	16,004	2.04
Leominster Elec. Lt. & Pr. Co	15,590	2.69
Clinton Gas Lt. Co	15,511	1.55
Newburyport Gas & Elec. Co	14,675	1.77
Hyde Park Elec. Lt. Co	14,510	7.45
Milford Elec. Lt. & Pr. Co	14,153	1.49
Plymouth Elec. Lt. Co	13,324	2.24
Adams Gas Lt. Co	12,846	1.40
Attleboro Steam & Elec. Co	12,702	4.17
Gardner Elec. Lt. Co	12,012	1.86
Medfield Elec. Lt. & Pr. Co	11,743	1.66
Plymouth Lt. & Pr. Co	11,585	3 07
Abington & Rockland E. L. & P. Co	11,368	2.68
Uxbridge & Northbridge Elec. Co.	11,281	2.58
Southbridge Gas & Elec. Co	11.000	1.37

The table indicates absolutely no relation between gross earnings per capita and population, but does indicate in a general way the extent to which electricity is used. The minimum rate of charge would have to be considered before a final idea could be obtained of the relative saturation of the different communities. Hyde Park, for example, earns $7.45 per capita, in part on an incandescent rate of 20 cents per kilowatt-hour, whereas Milford, a community of about the same size, earns $1.49 per capita, with a minimum incandescent rate of 15 cents per kilowatt-hour in bulk.

Rate variations will allow for some of these differences, but not all. From $3 to $5 gross earnings per capita is certainly the result of very active efforts, and, in many cases, of thoroughly organized methods of new business getting. No two communities are alike in all their characteristics, but it is certainly singular that in as small a State as Massachusetts there should be so much variation in the operation of the different central stations.

Table V. gives the gross earnings per ton of coal of nineteen stations burning coal alone, without screenings, wood or water power:—

TABLE V

Company	Gross Earnings Per Ton of Coal
Southbridge Gas & Elec. Co	$53.50
Worcester Elec. Lt. Co	44.80
Edison Elec. Ill. Co., Boston	42.00
Walden Elec. Co	39.00
Abington & Rockland Elec. Lt. & Pr. Co	34 90
Cambridge Elec. Lt. Co.	33.40
Lowell Elec. Lt. Corp'n	31.40
Salem Elec. Ltg. Co	30.70
Fall River Elec. Lt. Co	30.20
Waltham Gas Lt. Co	29.30
Cent. Mass. Elec. Co	22.00
Leominster Elec. Lt. & Pr. Co	20.63
Medfield Elec. Lt. & Power Co	20.25
Northampton Elec. Ltg. Co	19.80
Attleboro Steam & Elec. Co	19.20
Plymouth Elec. Lt. Co	19.00
Gardner Elec. Lt. Co	17.60
Uxbridge & Northbridge Elec. Co	12.30

The principal significance of these figures is the diversity of results found within the confines of a single State. In some quarters the gross earnings per ton of coal are considered to represent in a general way the working results of the generating and distributing plants as a complete system. The quality of coal and the rates enter as prominent variables, so that direct comparison is scarcely possible between the various stations, further than to use the figures as an earnest of the intensity with which the production of each

plant is forced, on the basis of the ton of coal as the raw material.

It is desirable for every plant to force these results as high as possible, and any likely difference in rates and coal quality is scarcely able to destroy the relative status of the upper and lower groups. Analysis of central station operations cannot be made with helpful results unless the work of every station is studied from all possible points of view. There are companies operating in Massachusetts to-day which are at their best in reference to station economy, and which are poor exhibitions in reference to the outside field of service; others are admirable in their dealings with the public and their customers, but behind the times in production. The opportunities for making the best of the means at hand in the central station business were probably never brighter than they are to-day, nor the reward of intelligent work more certain.

Book News

Notes on Electrochemistry

By F. G. Wiechmann, Ph. D. Published by the McGraw Publishing Company, New York. Size, 5½ by 8 inches; 145 pages. Price, $2.

This little book appeals to two classes of readers,—the student entering upon the study of electrochemistry, and the chemist interested in the application of electrical energy to chemical problems. The notes give a clear and concise presentation of the general principles which underlie electrochemical science.

The notes are of a general character, serving merely as an introduction to the study of electrochemistry and as an aid in securing an understanding and appreciation of the special branches of the subject. Prefacing each chapter, however, is a bibliography of standard publications which treat in detail of the theories of the science, the methods of electrochemical analysis, and the application of electrochemistry; all these works have been consulted by the author in the preparation of the notes.

While it is not so stated, it is presumably the intention of the author, in mentioning these books, to aid the reader in choosing the proper publications by means of which he may pursue the study of the various branches of electrochemistry more in detail.

Six chapters in the book are devoted, respectively, to general principles, electrical energy, electrochemistry, electrolytic dissociation, electro-analysis, and electrotechnology. There are also two indexes,—one of the proper names referred to in the text matter, and the other of the subject mentioned.

The Seven Follies of Science

By John Phin; 5½ by 7½ inches; 178 pages; 34 illustrations. Published by the D. Van Nostrand Company, New York. Price, $1.25.

While most everyone has heard of the seven wonders of the world, comparatively few have heard of the seven follies of science. According to Mr. Phin, the latter are the squaring of the circle, the duplication of the cube, the trisection of an angle, perpetual motion, the transmutation of metals, the fixation of mercury, and the elixir of life.

Each of these seven follies is discussed in a clear and interesting way in the first part of the book. The squaring of the circle and the various attempts at perpetual motion are given considerably more attention than are the other follies.

From Archimedes, who is generally accorded the credit of the first attempt to solve the ratio of the circumference of a circle to its diameter in a scientific manner, and who found it to be between 3.1428 and 3.1408, down to Mr. Shanks, who, in 1873, carried the result to 707 places of decimals, the history of the process is traced. Under the respective headings of absurdities, fallacies, and frauds, thirteen different examples of so-called perpetual motion machines are illustrated and described.

A number of paradoxes, illusions, and marvels are then discussed, followed by a chapter on micrography or minute writing, and another on the illusions of the senses. The concluding portion of the book is devoted to curious arithmetical problems.

Many of the matters brought out in this book, although very old, are not generally known, and as they are easily put in practice, the work of the author will doubtless afford amusement to many.

Proceedings of the American Street and Interurban Railway Association

Proceedings, 1905-1906, of the American Street Railway Association, the Accountants' Association, and the Engineering Association. Size 6½ x 9½ inches. Illustrated. 1062 pages.

This volume contains the reports of the twenty-fourth annual meeting of the American Street Railway Association, the ninth annual meeting of the Street Railway Accountants' Association of America, and the third annual meeting of the American Railway Mechanical and Electrical Association.

The report of the meeting of the American Street Railway Association, held at the Philadelphia Museum, Philadelphia, Pa., September 27-28, 1905, shows careful preparation. An excellent portrait of Hon. W. Caryl Ely, president of the association, appears as the frontispiece.

It will be remembered, the American Street Railway Association was organized December 13, 1882, its name being latterly changed to the American Street and Interurban Railway Association. Its office is at 60 Wall Street, New York.

Four papers were read at the 1905-1906 meeting, entitled respectively, "Application of Gas Power to Electric Railway Service," "Electric Railway Equipment," "Notes on the Design of Large Gas Engines, with Special Reference to Railway Work," "The Single-Phase Railway System." These papers and the discussions on them are printed in full.

A full account is also given of the transactions of the various committees, and of the resolutions adopted.

The report of the meeting of the Street Railway Assountants' Association of America, also held at the Philadelphia Museum, September 28, 29, 1905, follows next in order. A portrait of W. G. Ross, president of the association, preceeds the report.

The president's address, the executive committee's report, the constitution and by-laws, and the question box come next, and then the papers presented and the reports of the various committees. The titles of the papers presented are as follows:—"The Cost of Carrying a Passenger;" "Interurban Fare Collections;" "Interurban Ticket Accounting;" "Accounting with Four Departments."

The American Railway Mechanical and Electrical Association is now known as the American Street and Interurban Railway Engineering Association. Its office is at 12 Woodward avenue, Detroit, Mich. The report of the meeting of this association, which was held in the South Building, Philadelphia Museum, September 25-26, 1905, is headed by a portrait of its president, Mr. C. F. Baker.

Included in this report is the president's address, the question box, and the following papers with the discussions on them:—"Power Distribution;" "The Power Station Load Factor as a Factor in the Cost of Operation;" "Multiple-Unit Systems of Train Control;" "The Treatment of Rail Joints;" "Joints and Track Construction in Philadelphia;" "Electrical Rail Welding;" "The Cast-Welding of Rail Joints;" "The Power Station;" "An Emergency Track Brake."

Report of the Ontario Hydro-Electric Power Commission

IN a recent report on the utilization of water powers within the jurisdiction of Ontario, the Hydro-Electric Power Commission appointed by the Government of that province has considered the questions of demand for electric power, undeveloped locations, rates and prices, savings, capital cost, power supplied by existing companies, and appraisement of undertaking. These are first discussed briefly by the commissioners and then at great length by the chief engineer of the commission.

TABLE I.—CAPITAL COST

Items	50,000 H. P. Development	75,000 H. P. Development	100,000 H. P. Development
	24-Hour Power Capacity		
Tunnel tail-race	$1,250,000	$1,250,000	$1,250,000
Headworks and canal	450,000	450,000	450,000
Wheelpit	500,000	700,000	700,000
Power house	300,000	450,000	600,000
Hydraulic equipment	1,080,000	1,440,000	1,980,000
Electric equipment	760,000	910,000	1,400,000
Transformer station and equipment	350,000	525,000	700,000
Office building and machine shop	100,000	100,000	100,000
Miscellaneous	75,000	75,000	75,000
	$4,865,000	$5,900,000	$7,255,000
Engineering and contingencies 10 per cent	485,000	590,000	725,000
	$5,350,000	$6,490,000	$7,980,000
Interest, two years, at 4 per cent	436,560	529,584	651,168
Total capital cost	$5,786,560	$7,019,584	$8,631,168
Per horse-power	$116	$94	$86

The report deals only with that part of Southwestern Ontario which, roughly speaking, lies south of the latitude of, but includes, Toronto, and which, in the report, is called the Niagara District.

In regard to the demand for electric power, the commissioners were satisfied that a market for at least 50,000 H. P. could be obtained within a reasonable radius of the Falls as soon as transmission lines could be constructed, and that this could be increased to at least 100,000 H. P. within five years. This is rather a conservative view, as the engineer's report says that, from data obtained by canvassing the towns and cities of the district, it was estimated that within a year or two after electric power was available the full load demand would reach 109,000 H. P.

TABLE II.—GENERATING PLANT—ESTIMATE OF YEARLY OPERATING CHARGES

Items	50,000 H. P. Development	75,000 H. P. Development	100,000 H. P. Development
Operating expenses, including administration	$57,900	$70,200	$86,300
Maintenance and repairs	115,700	140,400	172,600
Replacement fund	86,800	105,300	129,500
Interest at 4 per cent	231,400	280,800	345,200
Rental of water	52,500	65,000	77,500
Total yearly charges	$544,300	$661,700	$811,100

Little is said regarding undeveloped locations, as the engineer's report on these is not yet ready. However, the Falls seem to be the only water power of sufficient capacity for electrical development. The water from Lake Erie, utilized at the Niagara escarpment, is feasible at various points extending from and including Niagara Falls westward about twenty miles. Further west, the backbone between the escarpment and Lake Erie becomes too pronounced.

The present Niagara power companies in process of development in Ontario are as follows:—

The Hamilton Cataract Power, Light & Traction Company, present capacity, 16,000 H. P.; the Canadian Niagara Power Company, present capacity, 15,000 H. P.; the Ontario Power Company, present capacity, 30,000 H. P.; and the Electrical Development Company, not yet operating, but which is building a plant of 125,000 H. P.

Regarding the generation of power the report takes up first the question of purchasing power and then the construction of a new generating plant. In view of the fact that several companies have plants partially or nearly completed, and others have been granted charters and carried on considerable preliminary work, and also in view of the fact that transmission systems can be constructed in a shorter period than generating plants, it is considered better for a transmission company to purchase power. The cost of power delivered at municipal sub-stations has been based on an arbitrary price of $12 per 24-hour-horse-power per annum at the high-tension bus-bars of the generating station.

Should it, however, be considered advisable to build a plant, which would require four years to complete, the site chosen would be immediately above the intake of the Ontario Power Company, about 5000 feet distant, in a direct line from the crest of the Falls. The estimated cost is given in Table I.

This estimate is based on the best class of construction in keeping with the surroundings; the machinery of the generating plant to be 10,000-H. P. units, with one spare machine in each case.

In order to determine the cost per horse-power per year at the high-tension bus-bars of the transformer station, an allowance must be made for transforming losses, which, taken at 2½ per cent., will give net amounts of power as shown in Table III.

TABLE III.

Net amounts of power (horse-power)	48,750	73,125	97,500
Yearly cost of 24-hour power	$11.16	$9.05	$8.32
Percentage of capital cost	9.62	9.63	9.67

This estimate of yearly charges is based upon setting aside a sinking fund for replacements sufficient to renew various portions of the plant when worn out or obsolete. It has also been assumed that the rate of rental charged would be similar to that already in force in contracts between the Queen Victoria Niagara Falls Park Commissioners and existing power companies.

For the transmission lines would be purchased a private right-of-way over the entire district—100 feet wide between Niagara and Hamilton, 66 feet wide between Hamilton and Toronto, and 33 feet wide alongside of highways or railways for the remainder. The class of construction adopted is that of steel towers; those from Niagara through Hamilton to Toronto being double, similar to those already erected by the Toronto-Niagara Power Company. For the remainder of the trunk lines, either double or single towers would be used, according to the number of lines; while branch lines would have a cedar pole construction.

The cost of power at the different sub-stations would vary from $15.36 per 24-hour-horse-power per annum in the division including Hamilton, to $30.87 at Dresden in Division V.

Three-phase current would be generated at 25 cycles and 11,000 volts, carried to a transformer station adjacent, and raised to 60,000 for distribution to the various districts. At Toronto, the distribution voltage would be 12,000, while at other places it would be 2200.

The extent to which the stealing of copper telegraph and telephone wire has developed in this country is indicated by the fact that more than forty wire thieves are now serving terms in the penitentiary.

Cleaning Metal by Means of the Electric Current

IN a paper read recently before the Faraday Society, of London, H. S. Coleman described an electrical method for cleaning iron and brass articles to be nickle-plated.

At first the articles to be cleaned were suspended in an iron tank containing a boiling solution of potassium hydrate, the articles being connected in an electric circuit as the anode, with the tank as the cathode. Current at 1.75 volts pressure flowed for five minutes. As a result, part of the grease was removed, but the surface of the work was covered with a brown deposit, which could not be removed by acid or cyanide dip.

The tank was then connected as the anode, and the current passed for five minutes at 1.5 volts. The work was free from grease and dirt, but the surface was covered with a lead-coloured stain or deposit, which could not be removed by acid dips, and only very slowly by a cyanide dip.

At this stage it was decided to try the effect of reversing the current, in order to remove this "stain" or "deposit," if possible. Repeating experiment 2, and waiting until the "stain" appeared, the current was then reversed. The result was very satisfactory; the "stain" disappeared, and the surface of the work became clear and bright.

A final experiment was performed to determine the current density required for successful working. This was as follows:—

Approximate area of work	8½ square feet
Current	68 amperes
Working current density	8 amperes per square foot
Potential	2½ volts

In experiment 1 the cathode (iron tank) did not show any signs of electrolytic action having taken place. In experiment 2, however, the anode (iron tank) was attacked, the surface being covered with a thin layer of oxide. This was anticipated from the fact that during the time that the work is the cathode the whole of the grease and dirt is removed, the reversal to anode being only necessary for the removal of the stain.

That the cleaning is due to an electrolytic, and not merely a chemical, change, the writer believed, for, unlike ordinary chemical potash cleaning, the same result is obtained by using a cold bath. The cleaning, however, is very much slower than with the hot bath. Electrolysis takes place, and minute quantities of metallic sodium (using sodium hydrate solution only) appear around the cathodes (work), and occasionally take fire.

In actual working it is much better to use the hot solution. By this process the grease, which consists chiefly of tallow, is saponified and remains in solution. The lighter dirt is thrown upon the surface of the bath and may be skimmed off, the remainder, consisting of very fine emery, falling to the bottom of the tank.

Ninth General Meeting of the American Electrochemical Society

THE ninth general meeting of the American Electrochemical Society was held in Morse Hall, the chemical laboratory of Cornell University, at Ithaca, N. Y., from May 1 to 3. The meeting was called to order by President Wilder D. Bancroft. President J. J. Schurman of the university welcomed the delegates, and the reports of officers were then received.

As a result of the recent election, the following officers were declared elected:—

President, Carl Hering, Philadelphia; vice-presidents, S. P. Sadtler, Philadelphia; J. W. Richards, South Bethlehem, Pa.; S. Reber, Washington, D. C.; secretary, S. S. Sadtler, Philadelphia; treasurer P. G. Salom; managers, C. J. Reed, Philadelphia; C. F. Burgess, Madison, Wis.; E. G. Acheson, Niagara Falls, N. Y.

It was arranged to hold the next meeting in New York, during the latter part of September.

The list of papers read has already been given in THE ELECTRICAL AGE. Abstracts of some of them are given in this issue. On Tuesday evening, President Bancroft delivered an address, taking for his subject "The Electrochemistry of Chemistry." He told first of those chemical reactions which apparently did not differ from electrochemical reactions. In other cases, there was no apparent similarity. Where there is any doubt, much time and effort may be saved by adopting the electrolytic method.

On Wednesday, announcement was made of the awarding of the Fresnel prize of $100 to Gustave Zin, of Paris. A. T. Lincoln, of the University of Illinois, also received a prize of $100 for investigating the corrosion of bronzes.

The afternoon of Tuesday was spent in visiting local plants and in inspecting some of the university buildings. In the afternoon of Wednesday the university buildings were again inspected, and the day closed with a banquet. On Thursday afternoon the works of the Remington Salt Company were visited, and E. G. Acheson delivered a lecture on "Carborundum, Graphite and Siloxicon."

Laying the Cornerstone of the United Engineering Building

ON Tuesday, May 8, at 5 P. M., Mrs. Andrew Carnegie laid the cornerstone of the United Engineering Building, on Fortieth street, in New York City. There was no formality about the ceremony, and outside of the members of the committee but few persons were present.

The cornerstone is of carved granite, and was placed over a metal box in which were placed several of the local newspapers, a copy of the Bible, and United States coins of all denominations. On a gold plate on the box was engraved the following:—

"To the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers and the Engineers' Club: It will give me great pleasure to devote, say, one and one-half millions of dollars to erect a union building for you all in New York City. With best wishes. Yours very truly,

"ANDREW CARNEGIE.

"March 11, 1904."

Mrs. Carnegie was presented with a silver trowel and an ivory gavel. Mr. Carnegie, in a brief speech, said that he congratulated the engineers on the near completion of the magnificent quarters. He was glad that it was a union home where the various branches of engineers could gather and discuss matters of interest. In Europe the engineering societies—mechanical, electrical and mining—were far apart. The American believed in mixing things. If the Europeans were to compete they would have to get closer together. The principle of union in science was correct. It was just as important as union in politics.

According to the Italian correspondent of "The Engineer," of London, almost every small hamlet in the greater part of the country is lighted by electricity. The motive power in most cases is derived from the turbines of great hydro-electric companies; but the use of electricity in Italy is so widespread that hosts of industrial firms have their own private plants, and are independent of outside help.

American Institute of Electrical Engineers

Cable Papers Read at the April Meeting in New York

Standardizing Rubber-Covered Wires and Cables

BY JOHN LANGAN

THE effect of the tendency toward high electrical pressures is nowhere more severely felt than in the requirement for insulated wires and cables, for insulation practically controls this feature of electrical distribution. Electrical pressures can, to be sure, be increased to almost any extent, and electrical energy be transmitted to almost any distance; but to control its pathway, to regulate its course, to prevent waste, and maintain safety, this is the problem,—the big underlying problem,—of all electrical distributions of to-day. Five hundred volts and under are easily controlled; but pressures of 5000, 10,000, or 20,000 volts introduce new problems, problems that were not even thought of in the days when 110 volts were considered standard practice.

On the distributing and not the generating medium, then, depends the success of the present tendency in electrical distribution. A badly insulated wire or cable will imperil the success of any system. Not only must the insulation itself be perfect, it must also be properly tested, properly installed, and properly protected. And, curiously enough, engineers, while examining carefully every other feature of a transmission system, will often pass lightly over the question of cables.

Cables, some appear to think, are all alike. If they possess the common identity of copper, this establishes a relationship of equality, and labouring under this very general illusion, rubber-covered cables are called for and purchased with no other restriction as to quality than that they shall conform to the National Code of the Board of Fire Underwriters' rules.

All this wire made subject to "code" rules passes under the general, but misleading, name of "rubber-covered," when, as a matter of fact, there is not an ounce of rubber in its composition. It is composed of cheap ingredients, rubber substitutes and the like, and bears about the same relation to fine rubber that a burnt cinder does to a lump of coal. Naturally, such insulation as this will not last long, since, having no rubber, it possesses no vitality, no dielectric strength, no capacity for work, and consequently becomes, in a short time, an easy prey to variations of temperature and climatic conditions.

The fault here lies not with the manufacturer, but with the rules; for the rules impose no provision as to quality. All they require is a certain diameter of insulation; but whether this diameter should be wholly or partly composed of mud or rubber, they are altogether silent. Of course, no one doubts the good intentions of the framers of these rules. But as indicating how wide of the mark they go in fulfilling any requirement of good insulation, let me quote here what the rules say about testing the wires before installation:—

"Each foot of the completed covering must show a dielectric strength sufficient to resist for five (5) minutes the application of 3000 volts per 1-64 of an inch thickness of insulation."

For example, they would require a conductor with 10-32-inch wall of insulation to stand a test of 60,000 volts, or a No. 14 wire which calls for 3-64-inch wall, a test of 9000 volts. The absurdity of these tests must be evident to anyone having the slightest familiarity with the practical side of electrical engineering. From what source such data were derived is hard to tell, for there is not the slightest warrant either in theory or in practice for it. Even the highest grade of fine Para would stand no such test, much less the cheap, bituminous rubbish that enters virtually into every foot of what is termed "code wire."

The rules say that the insulation must stand 3000 volts for every 1-64-inch wall of insulation. This requirement is, to be sure, absurd. But supposing this possible, who is to enforce it? No one, and no one does. The situation is like a body of law-givers formulating an arbitrary law, but making absolutely no provision for anyone to enforce the law.

In the case of the big telephone, telegraph and power companies, in or contiguous to New York, that is, contiguous to the manufacturers, this is simple enough, as they send a qualified engineer to make the necessary tests at the manufacturer's plant. But what is the engineer or consumer to do who lives in New Orleans or San Francisco or Chicago? Clearly he cannot journey to New York to test his wire, and so is forced to accept any old thing that is called "rubber-covered" when, as a matter of fact, it might be entirely destitute of any rubber.

The object, then, of this paper is to point out and define means of standardizing rubber insulation. There is now no standard, no guide, nothing whatever to compel a uniformity of compound, excepting such as is obtained through a tedious and expensive chemical analysis.

With variable and uncertain premises, you cannot avoid variable and uncertain conclusions. And it is because of this widely varying character of rubber insulation that nearly all such formula are uncertain and misleading. Under existing conditions, then, the electrical engineer has little in the way of data to guide him in obtaining reliable insulation.

This sounds very heterodox, for if there is any one dogmatism to which electrical practice seems unchangeably attached, it is that of a firm belief in the value of a voltage test in determining dielectric efficiency. Yet nothing could be more misleading. Indeed, it may be affirmed that a potential test is, in itself, no criterion whatever of permanent value. As an aid,—as a collateral agent,—it does, however, play an important part. But as indicating, much less proving, permanent merit, nothing could be more misleading and empirical. And the reason for this will, on a little reflection, be obvious enough.

You are all familiar with the influence of certain oils on high-tension switches and transformers. These withstand potentials that, without these adventitious aids, would be altogether impossible. Certain mineral and vegetable oils will, therefore, stand extremely high pres-

sures, and in this we have a clue, and even a proof, why many obviously cheap insulating compounds stand very high potential tests, and yet will, in a short time, break down in actual service.

The logic of this anomalous condition is, that when these communicated oils in the compound evaporate,—as they will in a short time,—the temporary and adventitious virtues they possess disappear also, and the insulation, deprived of this artificial support, quickly falls into disintegration and decay. This is the inevitable history of all such combinations. The situation is somewhat akin to a horse "doped" for a race, who shows a surprising turn of speed for a short distance, and then suddenly collapses. From this it will be seen that a puncture test is, in itself, an uncertain proof of dielectric excellence.

What is it, then, that constitutes good insulation, and how can we ascertain and know it? This is the all-important question. With this assured, everything else logically follows. The consensus of opinion, derived alike from theoretical and practical experience, is that rubber is the best of all insulating materials. There will, it is believed, be little dissent from this established conclusion. Its use to-day is practically universal.

It has survived the vicissitudes of time and experience, and successfully refuted the claims of all alleged substitutes, and stands to-day the unrivaled and indisputable factor in transmission, without which electrical progress would be uncertain and precarious. We need not, therefore, retort to any detailed proof of rubber's right to insulating preeminence. Twenty years of practical experience justifies the wisdom of its use. In fact, it is the quantity and quality of the rubber in the compound that differentiates the grade, and determines the price of every wire and cable on the market.

But while rubber is the principal feature of good insulation, it is not the only feature. As a matter of fact, rubber in itself is valueless as an insulating medium. The reason for this is that in its native condition it absorbs a certain amount of moisture, and when exposed to the air readily oxidizes. These factors of disintegration naturally preclude its use as a distinct and separate constituent for insulating purposes. But in conjunction with other ingredients, and when allied with sulphur, and properly vulcanized, it becomes not only absolutely waterproof, but indeed, under normal conditions, one might say, indestructible.

From this it will be seen that there are two factors involved in good insulation. The fundamental thing is, of course, that the rubber be fine Para. But it does not matter how good the rubber is or how much of it is incorporated in the compound, if the vulcanization is not properly carried out, the insulation will be defective. In fact, it is hardly exaggerating things to say that the art, or the science, of rubber insulation resides chiefly in the proper understanding of vulcanization. This consists in the addition of a certain percentage of sulphur,—generally about 3 per cent.,—to the rubber and then subjecting this association to a certain temperature for a certain duration of time. The result is vulcanized rubber.

Vulcanization, then, is that more or less mysterious factor which gives the rubber longevity, durability and immunity from oxidation when exposed to atmospheric and other conditions. In short, it is what may be called "embalming" the rubber. Without it, rubber is absolutely worthless for insulating purposes; with it, it becomes, under normal conditions, virtually indestructible.

Bear in mind, however, that there are many and different grades of rubber, all varying in price, as in quality, and it is only by a knowledge and recognition of this wide diversity of character that an engineer can intelligently make up specifications and rigidly enforce them.

Chemically considered, rubber is differentiated by the amount of acetone soluble, the extractive or resinous matter which it contains, and physically by its tensile strength. Both, of course, are closely related; for where it is chemically poor, it is also physically weak.

In brief, a high percentage of resinous matter is indicative of the cheaper grades, such as African, Madagascar, and some South American products, and a low percentage indicates the best grades of fine Para, such as Bolivia, Maderia, and Up-River. The best grades differ little as to merit, whereas the others fluctuate a great deal as to quality and price. In the former, the resinous matter is as high as 20 per cent., and in the latter it seldom exceeds 1 per cent.

This, then, is the chemical reason for the high regard in which fine Para is held, and it is with this grade that the following specifications and tests will be exclusively associated. You will observe from this, that in proportion as rubber is high in extractive matter, its estimation is low; and vice versa, that as it is low in extractive matter, its price is high. In other words, both quality and price will vary inversely with the amount of resinous matter.

These commercial aspects are the result of practical experience, for it has been found that the life of rubber bears a direct relationship to the resinous matter it contains. It is, therefore, of evident importance to have an elementary knowledge of these characteristics; for it is a lack of this knowledge that is responsible for the wide and general mischief caused by the belief that all wires and cables called "rubber-covered" are alike, when, in reality, if they possess any rubber at all, they may have nothing in common but the copper conductor.

With the physical aspect of rubber all are, no doubt, more or less familiar. It is astonishingly strong; indeed, it is doubtful if a piece of fresh fine Para, of a few inches in diameter, could possibly be broken by the average man. It is very elastic, too, stretching to such an extent as to render a substance, in itself opaque, perfectly translucent.

Now, from an analysis of these facts, it will be perfectly obvious that, since rubber is in itself very strong and very elastic, these characteristics should be present in any insulated wire in proportion to the quantity and quality of the rubber in the insulation. And from this it would seem that good insulation resolves itself largely into a question of tensile strength. This, on the whole, is true. But owing to the immense influence exerted by vulcanization, this is subject to important modifications, which will be referred to and enlarged on.

It is well known that while vulcanization, when properly done, does not alter the constitution of rubber, yet it can be made to affect adversely or deceptively modify its behaviour. For example, if it is over-vulcanized it will become hard and somewhat brittle; and if under vulcanized, it will become flabby and inert. In either case the result is indicative of imperfect insulation, and will not fulfill the requirements of a tensile test. In the one case it will break, and in the other it will stretch, but not return.

Good insulation, then, is clearly indicated by its prompt return after being stretched several times to, say, three to four times its length. Stretching to three and one-half times its length, as above indicated, is, roughly speaking, equal to about 800 pounds to the square inch. But

bear in mind that merely stretching implies nothing; almost any kind of rubber will stretch.

But where the first-class rubber is, the insulation will jump back with a vigor somewhat similar to a magnetic pull. What, however, is aimed at in this test, is a tensile strain of not less than 800 pounds to the square inch, and, wherever practicable, this is much more effective in weeding out the cheaper grades of rubber than the elongation test alone is.

Now, it has been clearly and repeatedly proved that where there is 30 per cent. of fine Para in the insulation, this physical test is easily obtained. Of this there is not the slightest doubt. In obtaining this proof, every manufacturer on the American market unwittingly contributed to the result. It was felt that to rely on any one brand or any one make would be one-sided and inadequate, and so every grade or combination of grades of different manufacturers was chemically analyzed, in order to verify the physical tests obtained.

The object was to discover a physical test that would enable the electrical engineer to obtain by a simple, inexpensive method, what can, with precision, be obtained only by a tedious and expensive chemical analysis. The original calculations were based on the assumption that since 30 per cent. of Para does, unmistakably, produce the tensile tests already referred to, any insulation fulfilling these, must, necessarily, possess 30 per cent. also. But it was found that a combination of a lesser amount of Para and a large amount of a cheaper grade of rubber would initially, at any rate, produce the same test that 30 per cent. of fine Para would. But to do it successfully, the compound has to contain between 40 and 50 per cent. of this cheaper grade.

This can best be explained by a single example:—Bids were asked for on a 20,000-volt cable, the insulation to contain not less than 30 per cent. of fine Para, free from all shoddy, rubber substitutes, and the like. The first two samples submitted did not meet the physical test, and were rejected. The third experiment was successful, met all the requirements specified, electrically and physically, but on a chemical analysis, here is what it contained:—15 per cent. of Para and 30 per cent. of some cheaper grade of rubber, making, all told, 45 per cent. to meet the requirements of the specifications. Now, this is an extremely interesting exhibit, the import of which will, it is hoped, be evident to all.

The first lesson that it conveys is, that this physical test, rigidly enforced, precludes absolutely the use of shoddy, bituminous products, and even the cheap grades of rubber. The second is, that it takes 40 to 50 per cent. of a cheaper combination to do what 30 per cent. of pure Para will do.

Another way of looking at it is, that the physical test does not, in itself, prove that the insulating compound contains anything else but pure Para. This, to be sure, is a drawback to its exclusive use where the best results are wished for. But, on the other hand, if it does not give you the best, it does, at any rate, wipe out all cheap rubber substitutes, and gives you an insulation that, if not equal in durability to 30 per cent. of Para, is immeasurably superior to anything you can now obtain by any other means short of a chemical analysis.

This, in itself, is an immense advantage. It enables the distant engineer to do what he could not do heretofore, to tell off-hand what the character of the insulation is, that is, to strip the insulation from the wire, and test according to the specifications herein to follow. Anyone can verify the value of it by getting some code wire and applying this test to it, or indeed, for that matter, the best wire to be found on the market, and see what the comparison will reveal.

In this test we have, it is believed, a cure for the growing degeneration of National Code wire. It enables the Board of Underwriters, architects, and engineers, all who are responsible for this class of work, to test off-hand, and without expense or trouble, the character of the insulation.

But while it does all this, the fact remains that the physical test alone does not compel precise results, does not necessarily compel 30 per cent. of fine Para in the insulating compound. It does, however, compel 30 per cent. of rubber. This, as has already been said, is an immense advantage over the bituminous products ordinarily got. But there is rubber and rubber, as there are men and men.

How to obtain,—how to compel,—30 per cent. of fine Para in the insulating compound is, then, the problem, where the best and most enduring results are desired. There is, unfortunately, no way short of a chemical analysis of proving this. And even then, we are constantly beset by stubborn facts and obscure difficulties which may neutralize the value of an analysis unless the specifications be carefully worded.

For the chemist,—and he must be a very skillful one at that,—can prove nothing whatever except by imposing rigid restrictions as to what the compound shall contain. For example, were you merely to say that the compound shall contain 30 per cent. of rubber and leave it at that, then the analysis would prove nothing more than that there was 30 per cent. of rubber in it, but whether it was good, bad or middling rubber, it could not determine.

Now, this is one of the perplexities of a chemical analysis of rubber insulation. There is, however, a way of arriving at chemical precision, one which proves indubitably the character of the rubber employed.

In the earlier part of the paper it was noted that the extractive or resinous matter in the rubber differentiated its grade, that is, the best grade of rubber has seldom more than 1 per cent., and the cheaper, varying from 5 to 20 per cent. From this it will be seen that by limiting the amount of resinous or extractive matter that should appear on a chemical analysis in the compound, the grade of the rubber is thereby determined. Of this there is not the slightest doubt. It can be verified in the following way:—Ask for a price first on a wire or cable to contain, say, 30 per cent. of rubber, and compare the cost of this with another which calls for 30 per cent. of fine Para, the extractive matter in which, on a chemical analysis, shall not exceed from 3 to 5 per cent. To all who are keenly analytical, the question will naturally occur, why allow 3 to 5 per cent. of extractive matter in this analysis, when the fine Para itself has native to it only about 1 to 1½ per cent.?

In the first place, during vulcanization, the extractive matter in a 30 per cent. fine Para compound, for some cause, increases to about 3 per cent. We do not, at present, fully understand why this should be so, but it is so. And, in the next place, the addition of some extractive matter to this inherent or natural amount is considered by the manufacturers a good thing for the insulation. But the total in the completed or braided wire should never exceed 5 per cent., for beyond this limit the chemist cannot differentiate the grade of the rubber, and thus the value of the analysis is compromised and useless. For this reason, tests should be made on the completed wire, rather than on an unfinished sample.

The following specifications will, it is hoped, in view of what has been said, be intelligible to all.

SPECIFICATIONS FOR RUBBER-INSULATED WIRES AND CABLES

All conductors to have at least 98 per cent. conductivity and to be thoroughly and evenly tinned.

The insulating compound to contain not less than 30 per cent. and not more than 32 per cent. of fine Para rubber. No shoddy, reclaimed rubber, rubber substitutes, or the like, must, in any form, be in the compound, the extractive matter of which, when chemically analyzed, must not exceed 5 per cent.

All wires and cables properly insulated in accordance with the above provisions must, after forty-eight hours' immersion in water, at a temperature of 60 degrees Fahr., and before tape, braid, or lead is applied, show the following insulation resistance and voltage tests. Insulation test to be made with a battery of 100 volts after one minute's electrification.

B. & S. Gauge	Wall	Voltage Test for 1 Minute	Insulation Resistance
LOW POTENTIAL, 600 VOLTS			
No. 14 to 8	3-64 in.	1,000	1,000 megohms per mile
" 6 to 2	4-64 "	1,000	1,000 " "
" 1 to 4-0	5-64 "	1,000	1,000 " "
250,000 to 500,000 cir-mils	6-64 "	1,000	750 " "
550,000 to 1,000,000 "	7-64 "	1,000	500 " "
MEDIUM POTENTIAL, 3,500 VOLTS			
No. 14 to 8	2-32 in.	5,000	3,000 megohms per mile
" 6 to 2	3-32 "	5,000	2,500 " "
" 1 to 4-0	3-32 "	5,000	2,000 " "
250,000 to 500,000 cir-mils	3-23 "	5,000	1,000 " "
550,000 to 1,000,000 "	4-32 "	5,000	600 " "
5,000 VOLTS WORKING PRESSURE			
No. 4 to 4-0	6-32 in.	10,000	2,500 megohms per mile
250,000 to 500,000 cir-mils	6-32 in.	10,000	1,500 " "
550,000 to 1,000,000 "	6-32 "	10,000	1,000 " "
11,000 VOLTS WORKING PRESSURE			
No. 4 to 4-0	9-32 in.	15,000	4,000 megohms per mile
250,000 to 500,000 cir-mils	9-32 "	15,000	3,000 " "
550,000 to 1,000,000 "	9-32 "	15,000	1,500 " "
No. 4 to 4-0	10-32 "	20,000	5,000 " "
250,000 to 500,000 cir-mils	10-32 "	20,000	4,000 " "
550,000 to 1,000,000 "	10-32 "	20,000	2,500 " "
No. 4 to 4-0	12-32 "	20,000	6,000 " "
250,000 to 500,000 cir-mils	12-32 "	20,000	5,000 " "
550,000 to 1,000,000 "	12-32 "	20,000	3,000 " "

For railway signaling, fire alarm, telephone and telegraph purposes the walls of insulation should not be less than the following:—

B. & S. Gauge	Rubber Wall	Voltage Test for 1 Minute	Insulation Resistance per Mile
18	1-16 in.	1,000	3,000 Megohms
16	1-16 "	1,000	3,000 "
14	1-16 "	1,000	3,000 "
12	5-64 "	1,000	3,000 "
10	5-64 "	1,000	3,000 "
8	5-64 "	1,000	3,000 "
9	5-64 "	1,000	3,000 "
6	3-32 "	2,000	2,500 "
4	3-32 "	2,000	2,500 "
2	3-32 "	2,000	2,500 "
1	3-32 "	2,000	2,000 "
0	3-32 "	2,000	2,000 "
00	3-32 "	2,000	2,000 "
000	3-32 "	2,000	2,000 "
0000	3-32 "	2,000	2,000 "

ELONGATION TEST

In addition to the above tests, the insulating material of every wire must stand an elongation test of stretching three times its length several times, that is, a piece 2 inches long must stretch to 6 inches and promptly return to within 20 per cent. of its original length. It must then stretch four times without break or rupture and return to 25 per cent. of its original length.

This elongation test is intended principally for Code wire, and would, even by omitting all conditions as to rubber, compel results that would be entirely reliable and satisfactory for all conditions of Code use.

TENSILE TEST

Any piece of insulation, about ½ inch wide by 1-16 inch thick, stripped from the completed wire or cable, should stand a tensile strain of 800 pounds to the square inch, and stretch to 3½ times its length without rupture.

The following provision will be found useful:—The manufacturer must notify the electrical engineer when wire is ready for testing, and in no instance must shipment be made until notified of approval and acceptance as per above tests.

TESTS

In carrying out the tests embodied in these specifications, there is sought something quite different from the ordinary potential and electrical tests. Heretofore the electrical engineer, when he imposed any test at all, relied solely upon a puncture test. If it met these requirements he asked for nothing more. If a wire or cable withstood a very high puncture test, it was looked upon as a "prima facie" evidence of dielectric excellence, forgetting that, had the pressure been maintained a moment longer, the insulation might have broken down.

It is a most mischievous practice, and a wholly misleading notion of safety, to push a test up to, or even to approach closely the dielectric limit of the insulation; for it is no uncommon occurrence to find the very best insulation hopelessly injured by this practice. It may not be well known, but it is a fact, nevertheless, that it is the rise in temperature which accompanies a rise in potential that is so destructive of rubber insulation. The layers next the copper naturally feel these injurious effects first, and they thus successively carbonize and break down with this increasing elevation of pressure and temperature.

It frequently happens that a cable may pass an exacting puncture test, and be to all appearances in first-class condition, when in reality the insulation has been so strained that it collapses at the first physical or potential strain imposed upon it. This is a frequent occurrence. A potential test is not, therefore, in itself an exact nor even an approximate proof of insulating merit.

You must not, however, assume from this that puncture tests are of no value, for they are, and of great value; but to be of value they must be employed, not as a means to destroy merit, but to discover imperfections. Here should be their chief object, and in this respect they are of incalculable importance to the electrical engineer.

It is obvious that a cable may be well made up of very poor material, or it may be imperfectly made up of the very best material. In the one case, there is good workmanship with poor material, and in the other, bad workmanship with good material. In the first case the cable is intrinsically poor, and in the second it is intrinsically good, but imperfectly made up.

This imperfection may be slight or considerable; it may be due to a piece of gravel or an air-bubble in the compound. In a case like this, nothing but a puncture test will discover the fault. But the test should be nominal, and there is no need of pushing it to the point of rupture. If there is any weakness or imperfection, 5000, 10,000, or 15,000 volts, depending on the thickness of the wall of insulation, will discover it, after one minute's application.

It may be laid down as a safe, general rule that a puncture test should never exceed double the working pressure, but this is true only up to a certain limit, say, 15,000 volts working pressure. After 25,000 to 30,000 volts are reached, the temperature increases so fast that it becomes increasingly destructive to the vitality and durability of the insulation.

Much of the present tendency for high-potential and break-down tests

is the result of an altogether erroneous comparison with tests imposed on paper-insulated and similar cables, which must, of course, be lead-covered before any test can be made. Such tests are, of necessity, "dry tests," whereas rubber-covered cables, on the contrary, are soaked in water and tested before the tape, braid, or lead is applied.

For this reason it is hardly an exaggeration to say that double the potential imposed on a paper cable is no more exacting than half the amount applied to a rubber cable. To expect, then, on a rubber cable anything like the same strain that is ordinarily put on a paper cable, would be, in effect, expecting rubber to stand double what paper stands.

In saying this, there is no intention whatever to institute comparisons between rubber and paper, or detract in any way from the merited recognition accorded to paper for certain work. All that is intended is merely to point out the fallacy of comparing tests, that, in their very nature, admit of no comparison.

The specifications and tests here incorporated will, it is hoped, obviate this well-meaning but destructive practice. The really vital point is to make sure of the rubber in the insulation, and this being assured by the tests referred to, all that is needed in the way of a potential test is enough to disclose imperfections arising during the process of manufacture.

The virtue of an insulation test is yet imperfectly recognized by the electrical profession. In fact, engineers in general altogether underestimate the value of a high insulation resistance. It will doubtless surprise many to hear that as a criterion of merit, it is immeasurably better than a voltage test. The probable explanation of this seeming paradox is, that while a cheap compound will stand initially a high potential test, the current, because of this cheapness, will sneak through it, and show a low insulation resistance.

Conversely, then, a high insulation resistance is indicative of a high-grade compound. At any rate, this much is certain, that in insulating compounds having 30 per cent. fine Para, there is always associated with them a very high insulation resistance; whereas in cheap compounds, the reverse is equally evident. In Code wire, for example, one cannot get over 400 or 500 megohms per mile, while the best grade of rubber will show three or four times this amount.

A high insulation test should, therefore, wherever possible, always supplement a physical test, as it tends to elevate the grade of the compound. When, however, a chemical analysis is contemplated, the necessity for this is not so obvious; but where it is not, the two, if associated, will produce the most satisfactory results.

The reason for limiting the rubber in the compound so as not to exceed 32 per cent. is this: it was found that by incorporating a large amount of cheap rubber with a small amount of Para the physical test could be nominally complied with, thus defeating the intention of the specification to obtain the best insulation. The object of this limitation, then, is that by not permitting fine Para, or any other rubber, in excess of this amount, the best rubber has to be employed to meet the requirements of the physical test.

Obviously, one manufacturer cannot afford to use 35 to 40 per cent. of fine Para at a materially less price than another who uses only 30 per cent., and where an analysis reveals such large amounts, or anything in excess of this limitation, there can be no doubt whatever as to the inferior grade of rubber used. This provision, then, is extremely important, because with its compulsory observance there would be little need of a chemical analysis at all, except in the event of a dispute, when it could be resorted to as a final court of appeal.

The tensile test is, under the limits referred to, sufficiently reliable and adequate for every purpose, for in it we have a means of standardizing rubber insulation that can neither be evaded nor denied.

Comments on Present Underground Cable Practice

BY WALLACE S. CLARK

THERE are certain practices now so general in underground cable work for light and power in America as to be almost standard. Some of these practices may be examined with advantage.

Cable making was an established art at least a quarter of a century before cables were made for service beyond signal transmission. Its development, therefore, has been somewhat more gradual than the development of the apparatus for generating the energy transmitted. Perhaps this greater age has tended to undue conservatism.

Practically all cables of the class under consideration have continuous metallic sheaths. Is this the best engineering?

LOW-TENSION CABLES

These are run in conduits with some portion of the circuit grounded. In railway practice, one leg of a two-wire circuit, and in lighting, the neutral wire, is permanently earthed. The continuous sheath on these cables is an invitation to stray currents and consequent electrolysis. While dry, well-vitrified tile is a fair insulator, in time the joints between the sections provide leaky spots. Further, many ducts are damp at certain seasons, if not during the entire year, making the dirt which accumulates a sufficiently good conductor to offer an additional path for stray currents.

Grounding the sheath at each manhole was announced as a cure for electrolysis, but instead of a cure it has been found in some cases to be a cause of trouble. The amount of current carried by the sheath is greatly increased, producing a drop in electromotive force between ground strips sufficient to cause a flow of current to earth at some intermediate point in the duct and in sufficient volume to give trouble.

In case of a burn-out, the continuity of the sheath aggravates the trouble. Whether the initial fault is in the duct or in a manhole, the tendency of the arc is to travel along the cable and without a sufficient volume of current to operate safety devices, if such are in the circuit.

If at any point another continuous metallic sheath comes within reach of the travelling arc, the fine earth it offers insures two cables out of service. Almost every large installation can furnish from its history a serious and expensive experience, illustrating this point. Further, during the burn-out a heavy current flows in the sheath, and this may leave the sheath by arcing to earth on some perfectly good section of cable, melting a hole in the lead.

The volume of current carried by these low-tension conductors in regular practice is so large that in many cases circuit-breakers or fuses will not operate with the current, due to the short circuit. The ammeters are a poor guide, especially in railway work. In many cases the outside end of the line is solidly connected to a network which is capable of furnishing all the energy needed to maintain the arc after the defective cable is disconnected at the station end; so we cannot depend on protective apparatus as used to-day for prevention of these troubles.

Omitting the sheath will cure all

the above ills. To do this would bar paper, lead-jacketted cables absolutely, and would increase the depreciation account if some type of cable insulation needing lead only, as wood needs paint, were used. Abandoning the lead entirely is an economic possibility with only very large conductors where it may be cheaper to renew the insulation on years, than to renew a lead jacket cable once in twenty years. These figures are, of course, merely used for comparison, for there is little accurate knowledge as to the life of insulated cables. If, therefore, we are compelled to use a lead sheath, the writer believes that it should be interrupted by some form of insulating joint on low-tension cables.

If this plan is carried out, a serious difficulty is the inability to test the insulation of the cable. This may be met by the use of an insulated wire,—proof or pressure wire,—in the outer layer of strands forming the copper core. Such a wire should be insulated with some material like treated paper susceptible to the absorption of moisture.

For the purpose of initial tests when cable is installed, the joints in the sheath may be bridged by fine fuse wires, which are afterwards removed. Several methods of utilizing the pressure wire are suggested below:—

(a) The outer end of the pressure wire is insulated, in which case periodic tests of this wire for insulation resistance will show any incipient fault in the main conductor. Between tests, the wire can be connected to a drop annunciator or other signaling device which will become operative in case of a burn-out, since the pressure wire will become "alive" before any great amount of energy flows through the fault. It might also be made to operate a current-interrupting device.

(b) The wire may be used to read the pressure at the far end of the line, the potential on the wire being opposite to that on the conductor in which it is embedded. A burn-out would reverse this potential and make the wire either "dead" or of the same potential and sign as the main conductor.

This change in potential could operate devices as above outlined under heading (a). If used in this way, the pressure wire would have to be disconnected at the far end for insulation tests, a much easier operation, however, than the disconnecting and insulating of the main conductor, and one not interfering with working the line.

A secondary use of the pressure wire would be to calculate the temperature of the main conductor by measuring variation in the resistance, figuring from length, loss in line, and known resistance cold.

HIGH-TENSION CABLES

With high-tension lines, some of the troubles due to the metallic sheath on low-tension cables are less marked. The load is usually more uniform and subject to less violent fluctuation, especially where sub-stations with batteries are in use, allowing protective devices to be set so as to operate more promptly. Further, in the case of a network, such cables are usually protected against a reversal of current, so that the arc at the fault is not maintained by energy derived from the network or sub-station.

The metal sheath on high-tension cables must be earthed to prevent danger to life, and also risk of puncturing the insulation by cumulative static charge. It is probably unnecessary to use insulating joints in the sheath of high-tension cables, except in some special case where local conditions require them to prevent an excessive amount of stray current being carried.

In the matter of sheaths, for a number of years the writer has been advocating multiple-conductor cables for arc circuits instead of several cables in the same duct in trunk lines. The running of a lot of small cables in one duct is not good practice; a burn-out on one cable is likely to injure others in the duct, and the withdrawal of a defective cable for repairs is apt mechanically to injure the other cables.

A properly designed multiple-conductor cable costs less, is easier to install, and safer to operate. Of course, one conductor in a duct is ideal, but is barred by cost in small sizes.

INSULATION

Should we use a heavy wall of a cheap so-called rubber compound or a lighter wall of better quality? Examination of engineers' specifications shows some curious ideas prevalent. Thick insulation has, among other points, these against it:—

1. Increased size of cable, involving increased cost of the sheath, duct space, and handling.

2. Thicker wall for heat generated in conductor to flow through (partly balanced by increased radiating surface), resulting in higher operating temperature in the copper core.

3. Most serious of all, however, is the frequent acceptance of a poor quality of compound having a very short life.

The last sentence contains a clue to the evil repute in which many engineers hold rubber-insulated conductors. There appears to be some confusion in the minds of engineers as to certain basic facts concerning what is generally called rubber insulation.

High-insulation resistance, high-puncturing resistance, and durability do not of necessity bear any relation to one another. An insulating material may have any one, or any two of these, and be deficient as to the remaining quality or qualities. High-puncture resistance is the least difficult; high insulation resistance somewhat more difficult, and durability the most difficult of attainment. A reasonable amount of good rubber in the present state of the art, as known to the writer, is necessary to insure durability.

The table of puncturing voltage, insulation resistance, and electrostatic capacity tests given herewith shows that these factors are not very good guides as to the durability of the insulation.

Relative Amount of Rubber	Breakdown. Electromotive Force	Insulation Resistance. Megohms per Mile	Capacity. Microfarads per Mile	Relative Deterioration in one Year in Elastic Limit
1	17 000 volts	534	2.	66 per cent
2	19,000 "	1,185	1 2	30 "
3	18,000 "	1,150	1.	20 "

The above figures are based on twelve tests of each class; they are quoted, not to show absolute values, but to make clear the point that the cheaper grades of insulation do not retain their elasticity. It should be noted that rubber compounds change quite rapidly at first, and that the rate of deterioration becomes less with time.

As an appendix to this paper, is a set of specifications adopted by the Rubber-Covered Wire Engineers' Association after more than a year's work. These specifications are better than any heretofore seen by the writer.

An idea of the life of a rubber cable leaded and operating at 11,000 volts, 25 cycles, is presented below through the kindness of Mr. H. Alverson, superintendent of the Cataract Power & Conduit Company, Buffalo:—

	Cable No. 2	Cable No. 3
In service Nov. 23, 1897	21,493 ft.	21,493 ft.
Added Jan. 22, 1299	10,559 "	10,559 "
Total in service from Jan. 22, 1899	32,052 ft.	32,059 ft.

BURN-OUTS

December 28, 1897, Cable No. 2, 20 feet from end of pole line; cause, no end-bells.

May 11, 1898, Cable No. 3, same as No. 2.

May 2, 1899, Cable No. 3, 8931 feet from end; cause, not ascertained.

October 12, 1899, Cable No. 3, 14,845 feet, end in joint.

1900, none.

1901, none.

May 17, 1902, Cable No. 2, 14,-224 feet from end in cable vault; mechanical injury.

1903, none.

September 19, 1904, Cable No. 2, 14,204 feet from end; labourer drove gas pipe into conduit and cable.

1905, none.

March 27, 1906, none to date.

In May, 1900, Cable No. 2 was tested with 22,000 volts for twenty-four hours.

30% Rubber Compound. Meghoms per Mile. 60 Deg. Fahr. One Minute Electrification.

	3-64	2-32	5-64	3-32	7-64	4-32	5-32	6-32	7-32
1,000,000 cir. mils	----	----	----	----	200	210	235	265	300
900,000 "	----	----	----	----	235	250	280	315	360
800,000 "	----	----	---	----	270	290	335	370	420
700,000 "	----	----	----	----	305	325	370	420	480
600,000 "	----	----	----	----	340	365	420	470	540
500,000 "	----	----	----	350	375	405	465	525	600
400,000 "	----	----	----	390	420	450	530	600	670
300,000 "	----	----	----	430	470	505	590	680	750
250,000 "	----	----	----	455	500	540	630	720	810
4-0 stranded	----	----	440	480	520	565	660	750	840
3-0 "	----	----	450	490	535	580	675	770	860
2-0 "	----	----	460	500	545	590	690	790	880
1-0 "	----	----	490	540	590	650	760	860	950
1 solid	----	----	520	580	635	700	830	950	1,060
2 "	----	500	550	615	680	750	900	1,040	1,060
3 "	----	530	585	650	715	795	940	1,080	1,210
4 "	----	560	620	690	750	830	990	1,130	1,260
5 "	----	590	655	720	790	870	1,040	1,180	1,300
6 "	----	620	690	760	840	920	1,100	1,230	1,350
8 "	610	710	800	880	985	1,060	1,240	1 370	1,490
9 "	650	750	850	940	1,050	1,130	1,310	1,440	1,560
10 "	690	795	905	1,000	1,120	1,200	1,380	1,510	1,620
12 "	750	870	990	1,110	1,250	1,370	1,540	1,680	1 790
14 "	800	930	1,060	1,200	1,340	1,470	1,640	1,780	1,890

30% Rubber Compound. Voltage Test for 5 Minutes. For 30-Minute Test, take 80% of These Figures.

	Thickness of Insulation											
Size	3-64	4-64	5-64	6-64	7-64	4-33	5-32	6-32	7-32	8-32	9-32	10-32
1,000,000 to 550,000	----	----	----	----	4,000	6,000	10,000	14,000	18,000	22,000	26,000	30,000
500,000 to 250,000	----	----	----	4,000	6,000	8,000	12,000	16,000	20,000	24,000	28,000	32,000
4-0 to 1	----	----	4,000	6,000	8,000	10,000	14,000	18,000	22,000	26,000	30,000	34,000
2 to 7	----	4,000	6,000	8,000	10,000	12,000	16,000	20,000	24 000	28,000	32,000	36,000
8 to 14	3,000	5,000	7,000	9,000	11,000	13,000	17,000	21,000	25.000	----	----	-----

Size of cable, 3-0; conductors, 3; insulation on each conductor, 9-32-inch thick; no over-all jacket.

The most noticeable fact brought out is that although most of the cable is more than eight years old, there is no indication of any electro-chemical or other electrical action weakening the ability of the insulation to withstand the working pressure.

Further, these cables, originally operating alone, are now in multiple with about 32 miles of three-conductor cables, and, therefore, subjected in all probability to more severe strains due to surges than when first installed. These are, the writer believes, the oldest working rubber-insulated, 11,000-volt, three-phase cables in use to-day.

These data on rubber insulation are important, if, as the writer believes, cables for very high tension will be made with combined insulations of varying capacities, rather than with a homogeneous insulation of any insulating material now in use.

There is one more point which should be touched on, if only to repeat and emphasize what has already been said by Mr. Fisher*, that is, the lack of judgment used by engineers in specifying the thickness of the lead sheath.

Cables are, roughly, of two classes:—Those whose insulating material is not injured by submersion in reasonably clean water, and a second class which will not withstand such test. For cables of the first class, the metallic sheath is primarily for the purpose of lessening the rate of deterioration, and secondly, to protect against mechanical injury during installation. The sheath on these cables should be comparatively thin and be proportioned to the weight of the cable. The second class of insulation will only be serviceable so long as the sheath is intact, and, therefore, the metal should be heavier and show less variation as to its thickness with the weight of the cable.

The above does not mean an endorsement of the specifications which call for $\frac{1}{8}$-inch lead on No. 6 and also on 2,000,000 cir. mils, but rather the suggestion of a minimum thickness of 3-32-inch on paper and jute-insulated cables, increasing gradually in proportion to weight and diameter to, say, 5-32-inch on the largest cables ($2\frac{1}{2}$ inch) now in common commercial use.

In closing, the writer hopes that the Institute will take up actively the standardization of some of the principal dimensions of underground cables.

APPENDIX

Specifications 30 per cent. Rubber Insulating Compound.
Rubber-Covered Wire Engineers' Association

The compound shall contain not less than 30 per cent. by weight of fine dry Para rubber which has not previously been used in rubber compounds. The composition of the remaining 70 per cent. shall be left to the discretion of the manufacturer.

* Transactions, A. I. E. E., 1905, Vol. xxiv., pp. 397-414.

CHEMICAL

The vulcanized rubber compound shall contain not more than 6 per cent. by weight of acetone extract. For this determination, the acetone extraction shall be carried on for five hours in a Soxhlet extractor, as improved by Dr. C. O. Weber.

MECHANICAL

The rubber insulation shall be homogeneous in character, shall be placed concentrically about the conductor, and shall have a tensile strength of not less than 800 pounds per square inch.

A sample of vulcanized rubber compound, not less than 4 inches in length, shall be cut from the wire with a sharp knife held tangent to the copper. Marks shall be placed on the sample 2 inches apart. The sample shall be stretched until the marks are 6 inches apart and then immediately released; one minute after such release, the marks shall not be over $2\frac{3}{8}$ inches apart. The sample shall then be stretched until the marks are 9 inches apart before breaking.

For the purpose of these tests, care must be used in cutting to obtain a proper sample, and the manufacturer shall not be responsible for results obtained from samples imperfectly cut.

ELECTRICAL

Each and every length of conductor shall comply with the requirements given in the table on this page. The tests shall be made at the works of the manufacturer when the conductor is covered with vulcanized rubber, and before the application of other coverings than tape or braid.

Tests shall be made after at least twelve hours' submersion in water and while still immersed. The voltage specified shall be applied for five minutes. The insulation test shall follow the voltage test, shall be made with a battery of not less than 100 nor more than 500 volts, and the reading shall be taken after one minute's electrification. Where tests for acceptance are made by the purchaser on his own premises, such tests shall be made within ten days of receipt of wire or cable by purchaser.

INSPECTION

The purchaser may send to the works of the manufacturer a repre-

sentative who shall be afforded all necessary facilities to make the above specified electrical and mechanical tests, and also to assure himself that the 30 per cent. of rubber above specified is actually put into the compound; but he shall not be privileged to inquire what ingredients are used to make up the remaining 70 per cent. of the compound.

DISCUSSION

After concluding his paper, Mr. Clark said that the specifications were intended to cover only the rubber compound, and not to cover the wire, or the stranding, or anything of that sort, but, so far as possible, to be general. It was not expected by the man who got them up that everyone would want 30 per cent. rubber compound, but they were compiled with the idea of getting specifications which would enable a man who wanted a really high-grade rubber compound to specify 30 per cent. rubber compound to comply with these specifications, with the assurance that he would get, if he tested his material when he received it, pretty nearly what he asked for, or would have a good chance for rejecting it.

Henry W. Fisher, of the Standard Underground Cable Company, then opened the discussion. In regard to the value of a voltage test in determining dielectric efficiency, he said that he did not agree with Mr. Langan's statement that nothing could be more misleading, because there is a great difference in the dielectric strength of cables containing different amounts of Para. A compound containing 30 per cent., of course, may have one and one-half to two times the dielectric strength of compounds containing a small amount of Para to which is added a large amount of reclaimed rubber.

On account of this fact a voltage test which would not injure a cable insulated with 30 per cent. Para rubber might be sufficient to puncture a cable having a cheaper rubber compound, hence a voltage test can be made the means of determining, to a certain extent, the quality of the rubber compound. He agreed with Mr. Langan in the statement that other tests are necessary to determine the true quality of the rubber compound under consideration.

He criticized the statement that rubber is the best of all insulating materials, and that in conjunction with other ingredients, and when allied with sulphur and properly vulcanized, it becomes waterproof, and, under normal conditions, indestructible. It is certainly a fact that under certain conditions rubber is not the best insulating material; it will not withstand under voltage stress the continued application of high temperatures as well as other forms of insulations. Rubber also deteriorates rapidly under normal atmospheric conditions when placed out of doors.

Referring to the specifications for rubber insulated wires for cables as proposed by Mr. Langan, he thought it would be much better to make the test after the tape or braid was applied. In the application of the tape or braid, the threads of the cotton are apt to make indentations in the rubber, and consequently a test made afterward would not withstand as high voltage as the test made before, and so the test should be made after the braid or tape is applied.

The voltage tests recommended by Mr. Langan are entirely too low. As to the statement that the rise in temperature which accompanies a rise in potential is so destructive of rubber insulation, Mr. Fisher said that, with the proper kind of insulation and the proper voltage test, this rise of temperature should be very small. He fully realized that cables insulated with rubber compound of poor quality are not suitable for the very high voltage, because such compounds are not so strong electrically, and are more liable to become warm under high voltage tests.

A comparison between the high voltage tests recommended in both papers shows that those of the latter are at least one and one-half times those of the former. It was his opinion that the tests mentioned by Mr. Clark could be applied without in any way injuring the rubber of a properly designed cable. He did not wish it to be understood that the use of rubber-covered cables was not advisable, because they were for many purposes. The question of cost, however, often precludes the use of rubber. Moreover, there are some very prominent engineers in this country who, because of repeated burn-outs on rubber cables, are rather averse to them for high voltages. Scarcely anything has been said about saturated paper insulated cables for high voltages. Such cables certainly preponderate here and are giving excellent satisfaction.

Reclaimed rubber must be used in some cases on account of the cost. With cables for low voltage, 5000 or below, there is no objection at all to the use of reclaimed rubber, because such cables give perfect satisfaction.

In regard to Mr. Clark's use of a pressure wire imbedded in the strand for determining the deterioration in the cable, he believed that there would be no indication, for the reason that any moisture that came into the cable would have to go all the way through the insulation and into the strand, and before the moisture got into the pressure wire to indicate a low insulation resistance the cable would burn out. He did not quite understand why there was not a difference in the breakdown voltages in Table I. in Mr. Clark's paper. The first voltage is 17,000, the second 19,000, and the third 18,000. In the third cable there is three times as much rubber as in the first. If that is the case, the breakdown voltage should be considerably higher, and in the same way the second breakdown voltage should be considerably higher than the first.

In continuing the discussion, Henry G. Stott, of the Interborough Rapid Transit Company, said that the condition of specifications for rubber-covered cables is an extremely chaotic one at the present time. Every engineer has his own specifications, and the result is that we are almost entirely dependent upon the honesty of the manufacturers in building these cables.

In trying to determine some approximate method for making specifications for rubber-covered cables, he had obtained from a manufacturer a number of samples of rubber-covered wire. These wires were No. 10, covered with 3-32-inch rubber, having various percentages of Para. Mr. Stott then exhibited a number of curves showing the result of his tests.

The tests showed, said Mr. Stott, that a manufacturer who wishes to use reclaimed rubber can provide a cable which will show up better than a cable containing the specified amount of Para, by introducing a large amount of reclaimed rubber and thereby getting a very cheap compound. From these tests it would appear that the variation of the insulation resistance, or change of temperature, is the best measure we can put on at the present time of the amount of Para we have in the compound. The puncture test is also helpful, but not absolutely. The stretching test is absolutely unreliable, but the variation of insulation test, with the voltage test, which is in itself more or less a puncture test, is apparently an indication of the amount of Para.

Philip Torchio said he thought the standardizing of rubber-covered cables and wires a difficult problem. Cheap and reliable cables and wires for house service and other electrical

applications would lead to an increased demand where first cost is now an almost insurmountable difficulty to secure business. On a very much smaller scale, however, there is a demand for cables for extra high voltage installations, where the question of cost is rather a secondary consideration.

Outside of these requirements there is a very large field for use of cables for underground transmission and distribution of high and low-tension current. In this case paper insulated cables have been used in the majority of cases in preference to rubber insulated cables, mainly on account of the first cost, especially in the case of high-tension systems where the insulation cuts a big figure in the total cost of the cable.

The proposed specifications presented take it for granted that a wire or cable insulated with 30 per cent. of pure Para rubber is the best insulation that can be used for all rubber insulated wires and cables. The speaker knew from personal experience that for a certain class of requirements, cables built with less than 30 per cent. of pure rubber, mixed with other ingredients, would give a product of the same durability and life and the same general satisfaction as a 30 per cent. rubber cable, and save the purchaser a considerable percentage in cost.

He would not say that all manufacturers are using less than 30 per cent. Para in their cables and wires, but was certain that some of them do; and as long as they supply these wires and cables for the legitimate demand of purposes warranting engineers and contractors to make use of them, he did not see why the American Institute of Electrical Engineers should try to stop it. Even if an attempt were made to prevent it, he did not think it could possibly accomplish a change of this kind, which is caused by conditions created by competition beyond our control. But granting that it would be desirable to standardize the rubber insulated cables by specifying 30 per cent. pure Para rubber, how could we accomplish it?

The papers, in a nutshell, recommend two tests:—One, the acetone test, to determine the percentage of extractive matter in the compound, and the other a mechanical test of elongation and tensile strength. One of the papers recommends a limit of 5 per cent. of extractive matter of the total compound, the other 6 per cent. With these percentages it is proposed to absolutely prohibit the use of less than 30 per cent. of fine Para rubber in the compound.

It was to be regretted that Mr. Langan, in his paper, has not more clearly stated the fact that it is an impossibility at the present time for any chemist to directly determine the amount of pure Para rubber in a compound. He arrives at this amount by inferences and assumptions, by means of which he tries to assume how much of the rubber found in the compound is pure Para rubber and how much is inferior rubber.

With the 5 or 6 per cent. extractive matter limitation of the specifications, any manufacturer can use almost anything between 30 per cent. and nothing of pure Para rubber and still meet the specifications as to the 5 per cent limitation.

As to the mechanical test, Mr. Torchio had not had sufficient personal experience to enable him to say much as to their value. The United States Navy has specified these tests for the last two years, and as their specifications call for 40 per cent. pure Para rubber, they are justified in so doing for obtaining the satisfactory results which they must secure under peculiarly difficult conditions of transacting business.

Dr. A. E. Kennelly thought that the basis of the whole matter from an engineering standpoint is essentially the breakdown test. The purpose of a cable in the transmission of power is to withstand certain voltages, and if a system is to distribute at 10,000 volts the cable must be built to safely withstand 10,000 volts, and so much more above that as the incidents of the business may require.

The natural procedure would be to test samples of the cable for the breakdown test, both before and after the cable was put down, but not to subject a whole cable to anything like a breakdown test. If the cable is lead-covered and is not overheated, then after it has been in ordinary service, without being overloaded by surges, a test piece lying on a shelf ought to be in the same condition as a criterion of permanence as the actual cable that has been in daily use under electric stress. The point that when a cable is stressed, say to 15,000 volts, it is the inside layers that are crucially tested, has not received sufficient attention. The outside layer gets off very easily by comparison with the dielectric stress upon the inside layer, and the thickness of wall is only a very imperfect criterion as to the strength of the cable for a given voltage.

It does not really depend upon the thickness of the wall, but upon the ratio of the external thickness to the internal thickness, and it has always to be kept in mind that the maximum dielectric stress will be exerted upon the inside layer, although it is the total test that has to be preserved from the engineering standpoint, but the criterion must always be, in any scientific testing of cables, the maximum stress upon the inside layer. The tendency is more and more toward the development of cables in which the inside layers are of the best and strongest dielectric materials and the outside layers can be made up more and more of what might be called stuffing.

E. W. Stevenson, of the Hazard Manufacturing Company, said the statement that the pressure test is no criterion as to what a good insulation is, seemed to be rather a startling statement. However, he believed that the pressure tests should be combined with at least one or two other tests to verify what the former shows. As to rubber being the unrivaled and indisputable factor in transmission, his experience had been that when it comes to extreme high-tension transmission and heavy power work, paper has almost entirely supplanted rubber. Both have their relative positions and their special advantages.

Mr. Langan's remarks about vulcanization showed what care has to be taken in this particular process to insure proper covering. His remarks also about the different qualities of pure rubber were good, but he placed the fine Para in rather too exalted a position over some of the others. There are many good qualities of rubber that give excellent results, and these rubbers cannot be ignored by manufacturers.

The mechanical tests, such as the stretch and return, and also the pounds per square inch, are of the greatest importance, and if purchasers would be careful to specify some such requirements they would certainly be sure of getting a good article. He thought, however, that the acetone extract is excessive, as it is quite well known that 5 per cent will allow considerable proportion of inferior rubber, and this extract should not be any more than 4, or 3½ would be better; but considerable care must be taken in making such a test, as the Soxholet extractor, the apparatus generally specified, in the hands of one not thoroughly familiar with its operation, is likely to give inaccurate results. The temperature of operation, the time and quality of ingredients used must be so carefully watched that one must be thoroughly familiar

with all these points in order to assure himself that results are correct. However, the chemical analysis is not always practical, and fairly good results can be obtained from the previously mentioned mechanical tests.

Mr. Stevenson did not quite see the logic of Mr. Langan's statement that if a 30 per cent. compound of fine pure Para will be quite successful in meeting all the requirements specified, why manufacturers should be tempted to get around these figures by putting in 15 per cent. of pure Para and 30 per cent. of a cheaper grade, as a very small amount of figuring will show that in the former instance, with pure Para at $1.50 per pound and others at $1 per pound, the compound will cost 53 cents per pound, while in the latter it will cost 58 cents per pound, or, in other words, the fake compound will cost 12 per cent. more per pound than the genuine. Probably the latter compound would have a greater covering capacity than the former, but even then the loss would be at least 5 per cent. There is also reason to question the statement about an analysis showing the different percentages of Para and other rubber, as there is probably no chemist who could do it. Extractive matter varies with the period of vulcanization and cannot show percentage.

Mr. Stevenson concurred in the statement that excessive pressure test is unnecessary and dangerous, but thought Mr. Clark's rule of two and one-half times the working pressure quite within safe limits, and this is generally understood all over the country. However, there is no objection to Mr. Langan's rule of double the working pressure. He does not quite see why Mr. Langan should say in regard to "dry tests" on fibrous cables that they were not comparable with rubber tests when the latter is immersed, as the water only assumes the position of a sheath, after all, over the rubber wall, and, therefore, the word double seems to be rather an exaggeration.

The amount of rubber put in a compound, Townsend Wolcott said, may be gotten in different ways. The Signal Corps had found that the best way was to have an inspector at the works and see the compound mixed. The determination of the amount of rubber by the acetone extract is, of course, a very uncertain matter, and the chemists seem to be divided into two classes, those who say that Para rubber never has more than 2 per cent. acetone extract, and those who find it is more in certain cases.

An analysis made by a chemist in whom he had a great deal of confidence showed in one sample acetone extract running up to 3.76, the lowest being 2.03, the highest 3.76. The rubber, even of the poorest, is not a definite chemical compound. The compound which is valuable may not constitute the whole of what is left, even after the acetone extract is made.

The relative values of the cables tested (four samples were analyzed) were given by this chemist, adopting one sample of rubber as an arbitrary standard. The values vary from 88.60 to 101.67 per cent.

Prof. Durand Woodman said that he had been interested in the subject of rubber insulation for five or six years and had done considerable chemical work on it. As to chemical tests being absolutely worthless, he doubted very much whether anyone who has had great experience with the chemical test would concur absolutely in that opinion. His own opinion was that when a set of specifications are finally adopted, they will include electrical tests, physical tests, and some chemical tests.

Before getting to the chemical analysis in particular, there is one point that has almost escaped attention, and that is the percentage of extract attained by treatment with acetone. The limits mentioned, 5 per cent. on the total compound, or 6 per cent., would mean on the rubber used, if you use 30 per cent. Para, from 16 to 20 per cent. from the rubber. It is, therefore, very necessary to consider very carefully whether one wants to adopt such a figure as 5 or even 6 per cent. of acetone extract, as that would certainly allow for rubbers that were not Para.

In regard to the time of the chemical analysis, that may be considerable or it may be little. The acetone extract, if it is desired, can be done in a very few hours, that is to say, a sample submitted one day can be reported on the next day, or even in less time. Twenty-four hours would give a reliable report as to the acetone extract.

A few other points are obtainable by the acetone extract, for instance, the amount of free sulphur, and while manufacturers are no doubt more careful than they used to be in regard to that, it is undoubtedly a thing which should be introduced into the specifications, as free sulphur is something that is subject to constant change in oxidation and shortens the life of the rubber.

William McClellan said that for a large proportion of the work that is to be done, 30 per cent. pure Para rubber is wholly unnecessary, and much too expensive; moreover, there is a large amount of very good rubber produced, not so fine as Para, but of the greatest use in the art of insulation.

A specification, to be standard, should be put in such a form as to permit the use of any percentage of any kind of rubber which the intelligent engineer may desire. Any specification which calls for 30 per cent. pure Para rubber uniformly, without regard to the particular use for which the insulation is designed, is fundamentally bad from an economic standpoint. It would frequently compel us to use a much more expensive insulation than is necessary, and it would deprive us of using many other rubbers which possess great merit, though not as great as fine Para.

Unfortunately, however, there is no test which is absolutely reliable in showing the percentage and quality of rubber in a compound; all tests proposed are indicative only, and must be used with the greatest caution.

As has been shown, the acetone test is positive in determining the quality of crude rubber; this test, however, is not applicable to rubber compounds, because very frequently the insulation manufacturer desires to introduce other substances with the rubber which contain in themselves extractive matter. Therefore, the extractive matter in a compound is absolutely no guide in determining the amount of rubber in the compound unless the specifications limit the substances which may be introduced into the compound: in other words, it is proposed to run the risk of requiring a more costly and less durable insulation in order that the acetone test may be applied to a rubber compound.

In the specifications proposed by Mr. Langan the implication is made that if the extractive matter becomes more than 5 or 6 per cent., the insulation will be bad, whereas for many purposes, as a matter of fact, the extractive matter could be considerably higher and a durable insulation obtained.

J. B. Taylor said that there was one point in connection with the installation or testing of high-voltage cables which has not been mentioned in the papers of the discussion, and that is the ability of the cable rubber or anything else to stand temporarily high potential. Cables have to stand for twenty-four hours a day a certain run in potential, and must do it pretty well except where trouble

develops at joints or the cable is improperly handled at places. Then comes a surge.

He thought the effect of surges is overestimated, but there is no question that any system will have occasionally high potential for a very short period of time, and it is important to know what the cable will do in the way of standing temporary high potential. It has been brought out in testing cables that it is important to mention the element of time,—in some cases 30 seconds, and in other cases a half hour or even an hour. If a cable will stand double potential for 30 minutes, will it stand 100,000 volts for one-tenth of a second?

The foregoing discussion of cable specifications seemed to Chas. F. Scott to be rather from the standpoint of the manufacturer, a study of the methods and materials used in manufacture. The cable is for use, and the real essence of a cable test should be to determine its reliability.

In the high-tension tests for other kinds of apparatus, as is the custom in general practice and as is laid down by the standardization rules of the Institute, we depend upon a certain high-voltage test that has been raised, with high-voltage apparatus in general, to twice the working voltage. Can the cable accept the same kind of a specification, the same limits, or must it have some other kind of a specification and some other kind of limit?

Must a man who wants a cable for a given service necessarily specify the ingredients of that cable and then go to the manufacturer and see it is put in and stirred up and baked properly, or is there some way to determine in the case of the cable whether it is going to do the service for him? If the high-tension test is to be applied, shall it be the same as for all other apparatus or shall it be something considerably less?

That matter was up for discussion at a meeting of the standardization committee recently, and it was seriously proposed that the test on cables should be considerably less than the tests of transformers. That would mean to the operating man that he has transformers which are better than the cables, and that some point in his cable would likely be the point of breakdown.

He thought the point brought up by Mr. Taylor very pertinent, that is, as to the time of the test. The time of one minute at some high voltage has been proposed. A cable is not likely to receive double voltage for a minute; it is much more likely to receive it for a fraction of a second. What is the relation between the strength of the cable and different voltages for different times, and would it not be fairer and better as determining the operating characteristics of the cable to make a higher voltage test for a shorter time?

President Wheeler said he had been quite astonished to find that the cable specification was in such an unsettled condition. He suggested to the secretary that at the meeting of the standardization committee he call their attention to the discussion, and suggest to them that they consider the matter and see what they can recommend, whether to have a special committee on the subject or to take the matter up themselves.

Secretary R. W. Pope said that he would turn the matter over to Dr. Kennelly, who is secretary of the standardization committee.

The president thought that the committee would better get right to work and devise methods by which the matter shall be handled. If there was one thing important, above all others, in engineering, it was standardization. He was glad to see the tremendous growth of the cable business and to see how the preparing and laying of cables has now become a matter of course.

He was not altogether unfamiliar with the subject of cables, because some time ago he was the equivalent of the electrician of New York City. From 1888 to about 1895 he had the job of getting the overhead wires in New York underground, and the wires all got between him and the Commissioner of Public Works, and they came down.

The discussion reminded him of the fact that when the companies were asked to take the wires down they practically said they could not make cables that would carry the electric current underground. Several cables were put underground and they sat up nights watching for it. The matter was written up in the papers, and everybody was watching to see whether the cable would carry the current so as to light the lamps the next night.

Then more cables were laid, and for two or three years a long and voluminous series of reports, with megohms and all sorts of things per mile, in them, were sent to him, and he was supposed to read them all and to see that all these cables that had been laid were kept up to the mark. It got to be a perfect farce, because the companies which did the work did it beautifully, and the company which dug the subways and tested these cables saw that they did not burn up the subways, and these reports were turned over to them and they saw that everything was done right.

In concluding the discussion, Mr. Langan said that many of the speakers in the discussion seemed to miss altogether the merit of his paper, which related specifically to the standardizing of rubber-covered wires and cables. As it is to-day, there is no standard. Ask any engineer of prominence in New York City to get up a set of specifications for rubber-covered wires and cables and he is at sea,—one will prescribe the voltage test, another the tensile test, and another the chemical test, one thing and another. There is no standard. If voltage is a certain criterion, as some of the gentlemen affect to believe, why are they at their wits' ends trying to improve the character of rubber insulation? Why is the standardization committee trying to improve the rubber insulation if the voltage test is the criterion?

Here is a curious illustration:—Send out proposals for a thousand feet, No. 14 wire code, and send out afterwards proposals for a thousand feet of No. 14 wire, 30 per cent. Para rubber, and the difference in price will amount to 50 per cent. Why? Because the amount of rubber in the latter case compels an increase in price. In other words, the commercial price indicates the character of the compound.

One of Mr. Fisher's points was as to the 1,000,000 C. M. cable, 12-32-inch wall, in which there is nearly 3000 meghoms per mile, and he questioned the possibility of that being lived up to. Mr. Langan asked, in return, why Mr. Fisher did not question the other insulation resistance? A cable of Mr. Fisher's own manufacture, No. 000, with 11-32-inch wall, shows up 6700 megohms with 30 per cent. rubber. The insulation resistance does, under favourable conditions, indicate indubitably the character of the compound.

No one could go above 500 or 600 meghoms with a code wire, whereas if 30 per cent. Para rubber, is put into it, it will give 4.5 and even 6 times what the code wire will show. That proves, first of all, that chemical analysis is valuable if carried out properly, and secondly, that the insulation does indicate the character of the compound.

In making out these tests, he was trying to get at a unity, something to start from, some common ground or specification on which to standardize. This does not interdict other

cables. He did not intend, in speaking of the Code wire, to have them employ 30 per cent. rubber in it. The stretching test is put in for the purpose of getting a good Code wire, but it is not the whole criterion of merit at all. It does not determine that the compound is pure rubber, but the tensile strength does come closely to it. It is a logical deduction to assume that where there is 30 or 40 per cent. of the Para rubber in the compound, some of the tenacity must be communicated to the compound.

Following Mr. Langan, Mr. Clark said that there were one or two things in Mr. Langan's paper he did not agree with, and, in fact, did not think they were so. In the first place, in speaking of the Code wire and the cheap material on it, he says, "It possesses no vitality, no dielectric strength, no capacity for work." There are a great many buildings in New York which are wired with that wire and are working, and it is altogether wrong to assume that rubber is the only possible insulating material. It is about the only elastic insulating material. There is no question about that much, but there are lots of mixtures which contain little rubber which are perfectly good for ordinary low-voltage service.

The second thing is the statement that rubber is unrivalled for all purposes. He agreed with Mr. Fisher that the statement is entirely too broad, and thought experience would bear that out. Mr. Langan also said that the percentage of resin and extractive matter in fine Para seldom exceeds 1 per cent. That was true ten years ago, but is not true to-day. The quality of fine Para rubber, as far as the resinous matter is concerned, is deteriorating . It averages now 2 per cent. or more.

Mr. Langan's voltage tests are entirely wrong in that he does not test the cable nearly high enough. He proposes on a 3500-volt working pressure to test for only 5000 volts, and his 250,000 C. M. cable with 3-32-inch insulation is to be tested at 5000. His 250,000 C. M. low-tension cable, with 3-32-inch rubber, is tested only for 1000 volts.

The voltage test should be a factor of the size of the cable and the thickness of the insulation. Then the engineer can determine the factor of safety he wants to have. If he wants to use a cable for four times, or twice, the working pressure, he can do it.

As to the statement, "It frequently happens that a cable may pass an exacting puncture test and be, to all appearances, in first-class condition, when in reality the insulation has been so strained that it collapses at the first physical or potential strain imposed upon it," Mr. Clark said that the cables for Niagara Falls, and the record of which was in his paper, were all tested for an hour with 25,000 volts, and they had a 9-32-inch insulation. Mr. Langan recommends for that 15,000 volts for one minute. According to his paper, these cables were overstrained, and they were likely to break down in service, and would break down. Yet they have made certainly a very decent record. There are 60,000 feet of cable in operation which contradicts that assertion.

If the cable is tested slowly, as Mr. Langan supposes, there might be an indentation in the cable which would reduce the insulation at one point to two-thirds or even one-half its normal thickness.

The test which had been proposed would not discover that fault, but a momentary high potential in service would discover that fault, and it is necessary to test high enough to find that out at the time of the test.

Referring to the statement regarding the difference in breakdown test and cables in water, Mr. Clark said it did not make any difference whether rubber cables were tested under water or in lead. He would rather test the cable under water, without lead, because it would stay cool better for high potentials.

Referring to the specifications of the Rubber-Covered Wire Engineers' Association referred to in his paper, he said they were not intended to cover all the wire manufactured. They were simply intended to cover the point where an engineer wants an especially good class of rubber insulation for some special work, such as a central station job, or something of that kind, where the life of the cable is important and the conditions more or less severe.

The reason that the 6 per cent. extractive matter is allowed is for the making of the best compound which the manufacturer is able to make with the 30 per cent. of Para. He can put in some other matter. His extractive matter from Para will not run to that, and the specifications take care of the fact that if the individual manufacturer is not trusted by the individual purchaser, the individual purchaser can go to the factory and satisfy himself that the 30 per cent. of Para goes in. The manufacturer can make the 70 per cent., the balance, of whatever he chooses to get the best results.

An Electrical Museum at Brussels, Belgium

IN October next there will be placed at the disposition of Belgians the Laboratory-Museum of Electricity of Brussels, built, equipped, and to be offered to the public by Robert Goldschmidt, of Brussels. The object of this philanthropic work is the development and extension of the use and application of electricity in Belgium by practical experimental instruction.

The institution will contain all kinds of electrical models and appliances, which may be freely handled for study and experiment.

Models and apparatus will be conveniently placed at the disposition of the public upon separate tables, and may be connected with the electric current at will. For example, a person desiring to familiarize himself with running an electric tramway, will find a complete model, about ten inches long, of an electric car, which he may freely handle for examination, and operate upon the diminutive rails. Reduced models of every part of an electric-tramway system, various dynamos, etc., are to be found in the museum. Mr. Goldschmidt hopes to extend the knowledge of the great possibilities of electricity through these practical methods..

The institution is divided into four large rooms. The first is devoted to machines serving to produce magnetic phenomena and electricity by friction and chemical reaction. This room will also be devoted to the demonstration of electrical laws.

A circular gallery around this room is designated as the second hall. Here are found machines of all sorts, lamps, bells, agricultural and dairy implements, conveniently exhibited, and worked by means of the electric current supplied to each table.

There will also be free telegraph, wireless telegraph, and telephone offices. The third hall is subdivided into reading rooms where the latest scientific periodicals will be on file. In the fourth hall will be found all kinds of large motors, dynamos, etc., which the public is at liberty to study and experiment with.

In Switzerland there are 296 electro-hydraulic stations in operation, capable of developing from 5½ horse-power to 12,000 horse-power each, the total power from all the stations being 175,000 horse-power. There is still available water-power for developing an additional 1,000,000 horse-power.

A Large Lighting Load in a Small Town

By ALTON D. ADAMS

ABOUT twenty years ago, Mount Peter and Prospect Rock looked down on a tragedy in gas, in the quiet valley of the Housatonic. Between these mountains lies the town of Great Barrington, Mass., where, until 1888, gas was used for public lighting.

During that year the incandescent electric lamp came into the valley, and as a result the gas system has long since been abandoned, sunk and wasted. Above the rusting remnants of the empty gas pipes there has risen an electric supply system with a commercial load of incandescent lamps nearly as great per unit of population as that in Boston, and greater than that in most other Massachusetts towns.

This first electric light plant in Great Barrington was equipped with one 95-H. P. boiler, one 80-H. P. engine, and two Edison dynamos, with a combined rating of 500 lamps of 16 candle-power each, connected on the three-wire system. About the middle of 1888 the system included 8820 feet of wire, and was operating 281 incandescent lamps for 49 consumers. The maximum rate was then $10 per 16 candle-power lamp per year, without regard to the number of hours of use.

Gas was distributed at Great Barrington by a corporation organized in 1853. In the fiscal year of 1888 this gas company sold 476,500 cubic feet of oil gas, at the rate of $4.80 per 1000 feet, and it then had 7920 feet of pipes that ranged from 1½ to 4 inches in diameter. At the open 5-foot flame, the gas gave 23.15 candle-power.

From this year, when electric supply began in the town, the output of gas declined, and in 1890, the last during which the gas company operated, the sales of gas amounted to only 367,000 feet, at the reduced price of $3.50 per thousand. Then the pipes were left to rust in the ground.

Up to 1895 the commercial load of incandescent lamps on the electric system at Great Barrington increased only gradually, and was 1000 lamps of 16 candle-power at the middle of the previous year, but had reached 1650 on June 30, 1895. During the year following this last-named date the electric system began to be operated with water power, and the consumption of coal was reduced to 274 tons, though 655 tons had been used for the year ending June 30, 1894.

This water power was a fall of 20 feet in the Housatonic River, and was over 5 miles distant from the distributing station at Great Barrington. At the water-power station the equipment included two sets of turbine wheels of 320 H. P. each, and of two 180-KW., 2200-volt, two-phase generators. This complete hydro-electric station was leased to the lighting company at a minimum rental that was below the coal bill of the previous year. From the date of this change to water power the rise of the commercial lighting load of the Great Barrington system has been rapid, and its consumption of coal has been very small.

TABLE SHOWING INCREASE OF LOAD OF THE GREAT BARRINGTON ELECTRIC LIGHT COMPANY

Year Ending June 30	No. of Commercial Incandescent Lamps	No of Customers	Lamps per Customer	Tons of Coal Burned	H.-P. Motors
1894....	1,000	69	14	655	...
1895....	1,650	97	17	274	...
1896....	1,850	108	17	9	...
1897....	.....	122	.	5	...
1898....	2,608	144	18	9	...
1899....	2,774	154	18	9	...
1900....	3,029	180	17	19	...
1901....	3,144	169	18	6	...
1902....	8,564	200	18	7	38
1903....	7,806	237	33	79	210
1904....	8,193	254	32	71	212¾
1905....	8,506	289	30	..	...

In 1903 the electric company secured another water power, located on the Housatonic River within about one-half mile of the business centre of the town, and installed there three more 2200-volt, 60-cycle, two-phase alternators, that raised the total capacity in machines of this type up to 678 K.W. In this second water-power station a power generator of 72-KW. capacity was also installed for special service in one of the factories supplied with power by the electric company. These generators in the Great Barrington station are belt-driven from a main shaft operating at 357 revolutions per minute, which is connected to horizontal turbine wheels of about 500-H. P. combined capacity.

A boiler of 150 H. P. and an engine of equal rating have been installed to provide for possible low water. The engine can be belt-connected to the shaft that is usually driven by the turbine wheels.

The table on this page shows that, starting with 1895, the year when the electric system changed from steam to water power, its load of commercial incandescent lamps has been multiplied more than five times in a decade. The same period saw the number of customers using these lamps more than doubled, and the lamps per customer increased from 17 to 30. Up to 1902 the number of incandescent lamps per consumer remained nearly constant, but in 1903, when the water-power plant at Great Barrington went into operation, the number of commercial incandescent lamps jumped from 3564 to 7806, and the number of these lamps per customer from 18 to 33.

This increase was due, in part, to the connection of the lighting loads of several factories to the lines of the electric supply system.

In 1895 the flat rate of $10 per 16-candle-power lamp per year was abandoned, and a meter rate of one cent per ampere-hour at 110 volts was established. For a customer using as much as 400 ampere-hours per month, the meter rate was three-quarter cent per ampere-hour. This rate was extended to all consumers in 1898, and, in 1900, the rate of 15 cents per kilowatt-hour was fixed.

Down to 1903 this last-named rate remained the maximum, but, in 1904, it was changed to 18 cents per kilowatt-hour, with a discount of 20 per cent. for payment by the 15th of the month, leaving 14.4 cents net, and so it remains. Commercial arc lighting is done at meter rates.

For the entire decade that water power has been in use, the consumption of coal has been trifling, and was greatest at 79 tons in 1903. Incandescent lamps are renewed free.

Besides its commercial load, the Great Barrington system operates about 233 incandescent street lamps of 32 nominal candle-power each during 3587 hours per year, for $19.25 per lamp. On the basis of 3.5 watts per candle-power, and,

therefore, 112 watts per lamp, this rate amounts to 4.7 cents per kilowatt-hour.

Prior to the fiscal year of 1902, the electric system at Great Barrington had no motor load, but in 1904 an aggregate capacity of 212 H. P. in motor capacity had been connected to its lines. These motors were operated with alternating current, some single phase and others two-phase, and were used in the factory of the Stanley Instrument Company, a pumping station, printing office, planing mill, for freight elevators, and minor purposes.

In comparison with other towns and cities of the State, the load of commercial incandescent lamps at Great Barrington is very large per unit of population. At the middle of 1904 the Edison Company, of Boston, was serving fourteen cities and towns with an aggregate population of 338,512, according to the census of 1900, and there were connected to its lines 545,166 commercial incandescent lamps, or 1610 lamps per 1000 of the population.

Great Barrington at the same time had 8193 commercial incandescent lamps connected to its electric system, and the population in 1900 was 5854, so that there were 1400 of these lamps per 1000 of the population. In other towns of about the same size the number of commercial incandescent lamps per 1000 of the population is usually between 200 and 700, so that Great Barrington has between two and three times as much commercial lighting as the average for towns of its size. Nearly all the commercial lighting at Great Barrington is now done through meters, and $1 per year is charged for use of the meter. Motor and lighting service is distributed through seventy-three transformers, three of which have a capacity of 300 lamps each, and three of 200 lamps each. For the year ending June 30, 1895, the gross income of the electric supply system at Great Barrington was $7,005.14, and for 1905, the corresponding electric income was $26,677.21, or nearly four times the former.

Of this income, $22,113.37 was received for lighting and $4,563.84 for electric power. Public lamps yielded $4,424.85, and commercial arc and incandescent lamps $17,688.52. On the basis of 212 horse-power of connected motor load, which seems to have been slightly below its actual figure for 1905, the income from this load was $21 per horse-power of its rated capacity during the twelve months ending with June 30 of that year.

For the same twelve months the income per commercial incandescent lamp connected to the system, after reducing the number of commercial arc lamps to their equivalent number of 16-candle-power incandescent lamps, was $2.04. This may be contrasted with the flat rate of $10 per lamp-year in 1894, when the entire load of the steam-driven electric station at Great Barrington, reduced to equivalent incandescent lamps, was represented by 1260 such lamps of 16 candle-power each. From this load the average electric income per lamp was $6.14 in that fiscal year.

Report of the International Waterways Commission

THE following report of the International Waterways Commission has been made to the Secretary of War by the American members and to the Canadian Minister of Public Works by the members of the commission from Canada:—

The commission has made a thorough investigation of the conditions existing at Niagara Falls, and the two sections have presented reports to their respective governments, setting forth these conditions to which attention is invited. The following views and recommendations are based upon a careful study of the facts and conditions set forth in these reports:—

1. In the opinion of the commission, it would be a sacrilege to destroy the scenic effect of Niagara Falls.

2. While the commission are not fully agreed as to the effect of diversions of water from Niagara Falls, all are of the opinion that more than 36,000 cubic feet per second on the Canadian side of the Niagara River or on the Niagara peninsula, and 18,500 cubic feet per second on the American side of the Niagara River, including diversions for power purposes on the Erie Canal, cannot be diverted without injury to Niagara Falls as a whole.

3. The commission, therefore, recommend that such diversions, exclusive of water required for domestic use or the service of locks in navigation canals, be limited on the Canadian side to 36,000 cubic feet per second, and on the United States side to 18,500 cubic feet per second, and in addition thereto a diversion for sanitary purposes not to exceed 10,000 cubic feet per second be authorized for the Chicago drainage canal, and that a treaty or legislation be had limiting these diversions to the quantities mentioned.

The effect of the diversion of water by the Chicago drainage canal upon the general navigation interests of the Great Lakes system will be considered in a separate report.

The Canadian section, while assenting to the above conclusions, did so upon the understanding that in connection therewith should be expressed their view that any treaty or arrangement as to the preservation of Niagara Falls should be limited to the term of twenty-five years and should also establish the principles applicable to all diversions or uses of waters adjacent to the international boundary and of all streams which flow across the boundary. The following principles are suggested:—

1. In all navigable waters the use for navigation purposes is of primary and paramount right. The Great Lakes system on the boundary between the United States and Canada and finding its outlet by the St. Lawrence to the sea should be maintained in its integrity.

2. Permanent or complete diversions of navigable waters or their tributary streams should only be permitted for domestic purposes and for the use of locks in navigation canals.

3. Diversions can be permitted of a temporary character, where the water is taken and returned again, when such diversions do not interfere in any way with the interests of navigation. In such cases each country is to have a right to diversion in equal quantities.

4. No obstruction or diversion shall be permitted in or upon any navigable water crossing the boundary or in or from streams tributary thereto which would injuriously affect navigation in either country.

5. Each country shall have the right of diversion for irrigation or extraordinary purposes in equal quantities of the waters of non-navigable streams crossing the international boundary.

6. A permanent joint commission can deal much more satisfactorily with the settlement of all disputes arising as to the application of these principles, and should be appointed. The American members are of opinion that the enunciation of principles to govern the making of a general treaty is not within the scope of their functions; moreover, the jurisdiction of the American members is restricted to the Great Lakes system.

A Héroult electric furnace for the refining of steel was recently started up at the works of the Halcomb Steel Company of Syracuse, N. Y. Steel is supplied in a molten state to the electric furnace.

Electricity as an Amusement Purveyor

Its Use for Fountain and Carnival Illumination

By DAY ALLEN WILLEY

The subject of spectacular illumination has been The Electrical Age very fully treated in in the past, but the attention now being given to methods of increasing current sales makes the present article of interest, showing as it does two fields offering excellent opportunities for the increased use of current.

AN ELECTRICALLY ILLUMINATED FOUNTAIN IN WHICH THE WATER IS MADE TO REPRESENT SHEAVES OF WHEAT

THE idea of the fountain for ornament dates back many centuries, as is shown by the discoveries of designs in excavating among the ruins of Pompeii. The famous fountains so often seen by the tourist in the cities of France and Italy are modeled after some of the fountains in ancient Rome, although advantage has been taken of the engineers' skill to produce far more picturesque effects. For example, the jet in the palace of Herrenhausen at Hanover rises to a height of no less than 200 feet, and probably reaches a greater altitude than any other aquatic display of this kind. The cascades in the gardens at Versailles are noted for their size and beauty, while the cities of Rouen and Marseilles have very large fountains of especially artistic design.

It is somewhat strange that only within a few years has the electric current been employed in connection with the illumination of moving water, thus creating what is known in this country as the electrical fountain. The first to attract general attention because of its picturesqueness was that designed by MacMonnies, forming one of the principal features of the Chicago Exposition in 1893. The superb electrical display attracted such attention that the electrical fountain for exhibition purposes became quite popular. Current generated at Niagara Falls was employed for a series of water illu-

NIGHT VIEW OF AN ELECTRIC FOUNTAIN IN WILLOW GROVE PARK, PHILADELPHIA

AN ELECTRIC FOUNTAIN WITH A CENTRAL FEMALE FIGURE. VARIOUS POSES ARE ASSUMED WHILE THE FOUNTAIN IS IN OPERATION

minations at the Pan-American Exposition, and electrical fountains were seen also at the World's Fair at St. Louis.

Really the term electrical fountain is a misnomer, for the current is usually employed merely for illumination, and not in forcing up the water from the basin or other form in which the fountain has been designed. This work is generally performed by the ordinary steam or hydraulic pump, where the location of the source of supply is not sufficiently elevated to furnish the requisite pressure. Several American fountains have been constructed, however, where the electric current is utilized for power as well as for producing the light effects.

A DAYLIGHT VIEW OF THE "SHEAVES OF WHEAT" DESIGN

One of the largest and most notable fountains in the United States of this class, is located in Willow Grove Park, in the suburbs of Philadelphia. It is designed entirely for amusement purposes, and the various shapes assumed by the water columns at nightfall, reflected as they are in the rays of the varied lights, form a spectacle which attracts thousands. The water required for this fountain aggregates 50,000 gallons every twenty-four hours, and is supplied by one large and one small pump, the larger being actuated by two 50 horse-power motors working on a 500-volt current.

In the basin which forms the lower portion are installed a series of lamps. The lamps individually, or in groups, are incased in globes of thick glass, so that they are thoroughly protected from the water. As the installation is under water, the wiring is heavily insulated, most of it being placed in water-tight conduits.

The masonry lining to the basin includes what might be called the operating chamber. This is a compartment having windows of thick glass, from which one can see all of the jets and the entire basin. It contains a row of levers somewhat similar in arrangement to those in the ordinary railroad block signal tower. Against one wall is the electrical switchboard, but in place of the ordinary switch, rows of push buttons are substituted. These buttons are tinted in red, white, blue, green, and are placed so that they can readily be manipulated by one hand if desired. This comprises the operating mechanism of the fountains.

The levers are attached to wires, which in turn lead to the valves inserted in the supply pipes, serving the various jets of the fountains. Consequently, by pulling a lever handle the water is turned on, the reverse motion, of course, shutting it off from the jet which is thus controlled. The electric current is controlled by means of the series of push buttons referred to.

The lamps are placed in such a position that some of them throw a ray of light obliquely upwards, while others illuminate the lower portion of the fountain. The groups include

the various colours referred to, besides the ordinary white—the red lamps being controlled by red buttons, the green lamps by green buttons, and so on.

If the operator desires to open all the valves, the levers are so arranged that at one motion he can perform this operation, when the fountain will, of course, throws jets from every nozzle. If he merely desires the white effect, he pushes the white button, and the illumination is all of one tint. By shutting off this circuit and pushing the red button, the water is turned to a rose colour. Following this may come the green or the yellow illumination, but as several combinations can be worked by means of the buttons, one portion of the water may be couloured with the red light and another with the green.

The design at Willow Grove Park contains so many figures of sprays and jets that the water columns can be formed into numerous shapes. For example, one strikingly resembles sheaves of wheat, and when illuminated by the vari-coloured lamps, the spectacle is, indeed, beautiful. Another representation is that of an enormous fan, which changes from white to red, green and yellow. Still another is what is called the spray fountain, which is one of the most attractive of the spectacles. The center jet of the fountain rises to a height of 125 feet, and is surrounded by several groups. When this combination is in play the fountain resembles a liquid monument. This curious open-air performance lasts over an hour, as the operator goes through a regular programme, introducing the various figures, and, as already stated, makes a large number of combinations, thanks to the installation of the lamps.

A DAYLIGHT VIEW OF THE FOUNTAIN SHOWN OPPOSITE WITH THE FIGURE POSING AS "COLUMBIA"

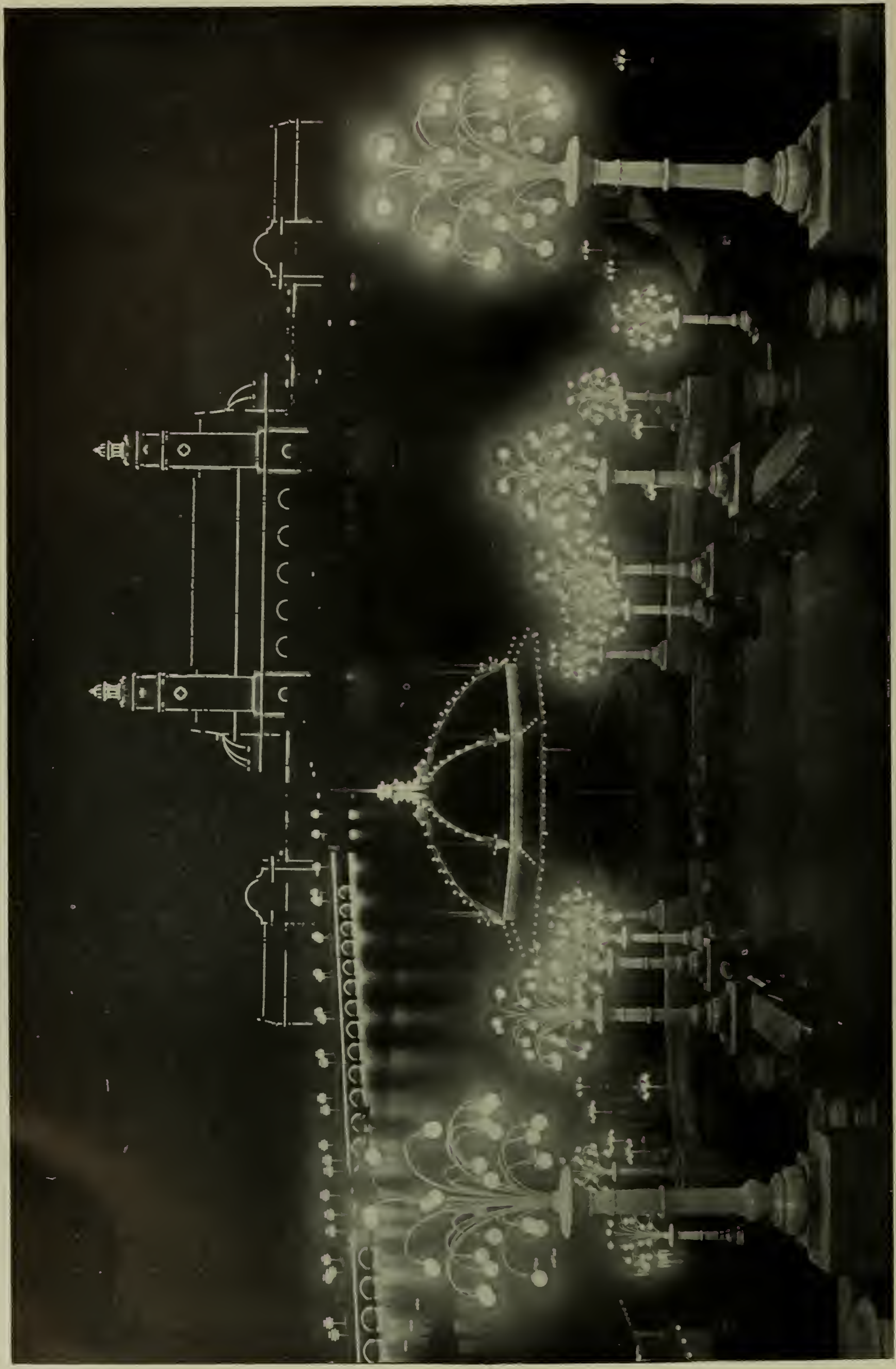
The designer of the Willow Grove fountain, F. W. Darlington, of Philadelphia, also designed the fountain in Prospect Park, Brooklyn, which at the time it was completed was the largest in the world. In this fountain there were nineteen funnels arranged in two circles, with one funnel in the exact center of the fountain. Each of these funnels was covered with glass, and from the center of the middle funnel rose a small pipe, which projected a central geyser jet high in the air.

It is this "geyser" which is seen in the center of the "Sheaves of Wheat" design at night, and in the "Geyser at Night," which forms, to use a mixed metaphor, the backbone of the electrical displays. The jets were so arranged as to form different designs—umbrella shapes, whirling designs, globular showers, criss-cross motions. The very pretty "wheat sheaf" design was made by streams of water from sixty-eight nozzles in the funnel, and when nineteen of these sheafs are being made, it brought over a thousand streams of water into play.

Two men were necessary to operate this fountain, one to manipulate the levers which govern the jets of water, and the other to control the search-lights. The chief operator looked out of two or three windows, just above the surface of the water in the basin, and through these he could see the effects of each movement of levers or colours. In front of him was a row of levers, each of which controlled the water to one set of fountain jets, and a long board, on which were arranged the push-buttons controlling the various combinations of colours.

The colour scheme in the Prospect Park fountain was very ingeniously arranged, the tints being given by movable discs of differently coloured glass, which were operated by pneumatic pressure; the air valves being controlled by electric circuits. Each lamp was encased in a bowl of clear glass, the discs being set in a recess inside of the bowl. If a green hue was desired, by pushing the corresponding button, this disc slid into position between the light and the bowl, and remained as long as the air pressure continued.

Each coloured button was installed in connection with a white button. By pressing the latter, the valve was closed and the disc slid back into its socket. The plan employed



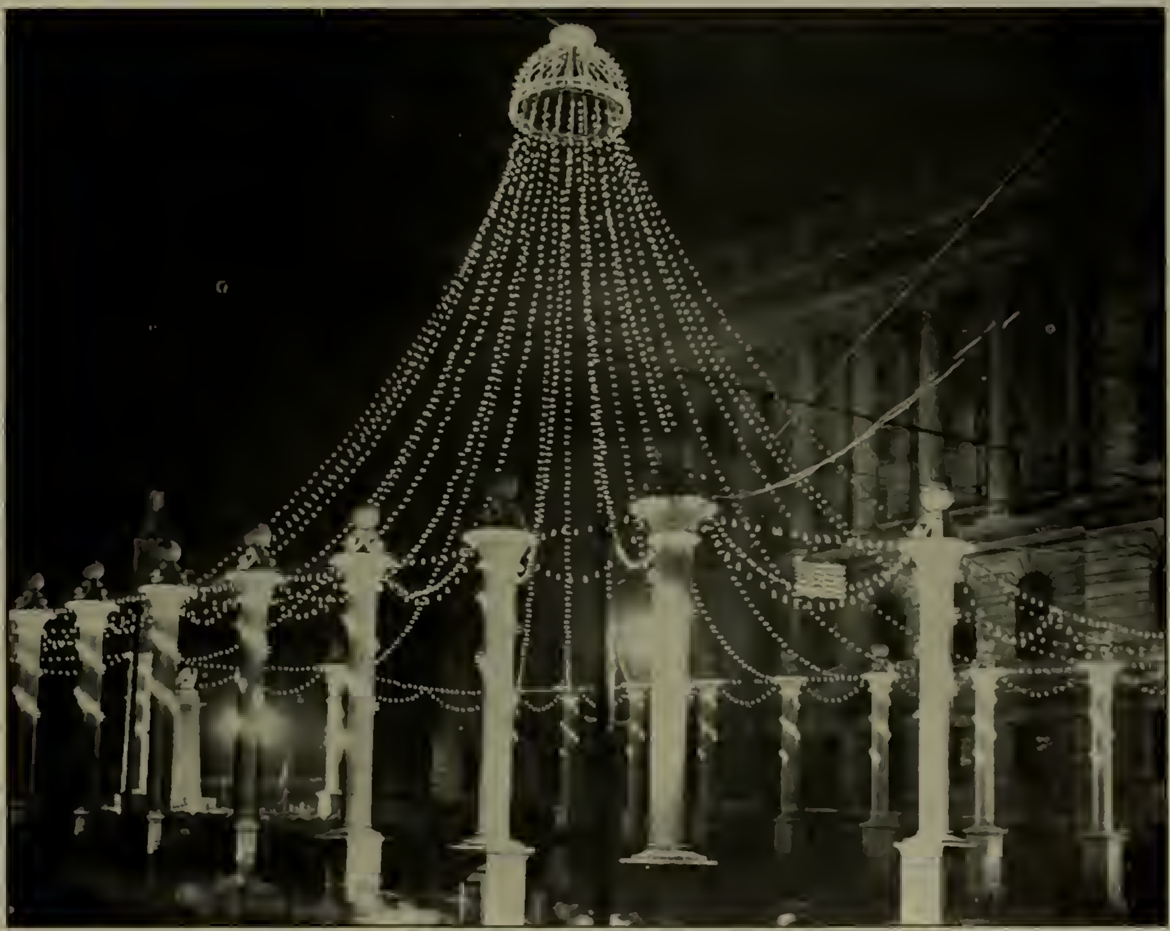
AN EFFECTIVE GROUPING OF INCANDESCENT LAMP CLUSTERS AT THE LEWIS AND CLARK EXPOSITION. NOWHERE MORE THAN AT EXPOSITIONS OF RECENT YEARS HAS THE VALUE OF ELECTRICITY IN SPECTACULAR ILLUMINATION BEEN SO THOROUGHLY DEMONSTRATED

ANOTHER VIEW OF THE WILLOW GROVE PARK FOUNTAIN, SHOWING ALSO THE ILLUMINATION OF SOME OF THE BUILDINGS

was somewhat similar to the disc block signals used on some of the railways of the United States. One of the series of discs in each bowl was opaque, so that at any time the illumination might be shut off.

The electric current has also been employed in illuminating some of the great natural fountains of this country. Everyone who has visited Niagara Falls within the last few years is familiar with the method by which the cataract has been lighted by the rays of powerful searchlights. One of the most picturesque spectacles of this sort is to be seen at Shasta Springs, in California. Here the water issues from the rock wall of the Sacramento Canyon, the upper portion of the cascades falling a distance of nearly 200 feet. Over a thousand incandescent lamps have been installed in various portions of the rock wall beneath the water, incased in water-tight glass globes, and connected with circuits of heavily insulated wire.

A 60-H. P. Pelton wheel, direct-connected to a generator, is utilized to supply the current. The cascades are illuminated every night and form a most attractive spectacle to passengers on the Southern Pacific Railroad between San Francisco and Portland, as the springs are directly on this route. It may be added that the power installation is not only sufficient to illuminate the falls, but to operate a cable railway, which extends from the bottom to the brink of the canyon, a distance of about 350 feet.



A COURT OF HONOUR DURING THE ELKS' CONVENTION IN BALTIMORE

THE ILLUMINATION OF THE LOG HOUSE AT THE LEWIS AND CLARK EXPOSITION WAS UNUSUALLY ATTRACTIVE. A NUMBER OF TREES SURROUNDED THE HOUSE, AND THESE WERE ALSO LIGHTED UP BY THE LAMPS ON THE OUTSIDE

ANOTHER EXAMPLE OF THE EXTERIOR ILLUMINATION OF BUILDINGS AT THE LEWIS AND CLARK EXPOSITION

ARCHES LIGHTED BY INCANDESCENT LAMPS DURING A CARNIVAL

The use of the electric current for amusement purposes has, in fact, become indispensable. It is needless to say what would be the effect if the theaters in the great cities were deprived of this element, merely for advertising purposes. The blaze of light for which Broadway is notable is furnished principally by the elaborate electrical signs, some of which contain over a thousand incandescent lamps. In short, electricity has become so much of a necessity for advertising purposes alone that no other form of illumination could be substituted for it.

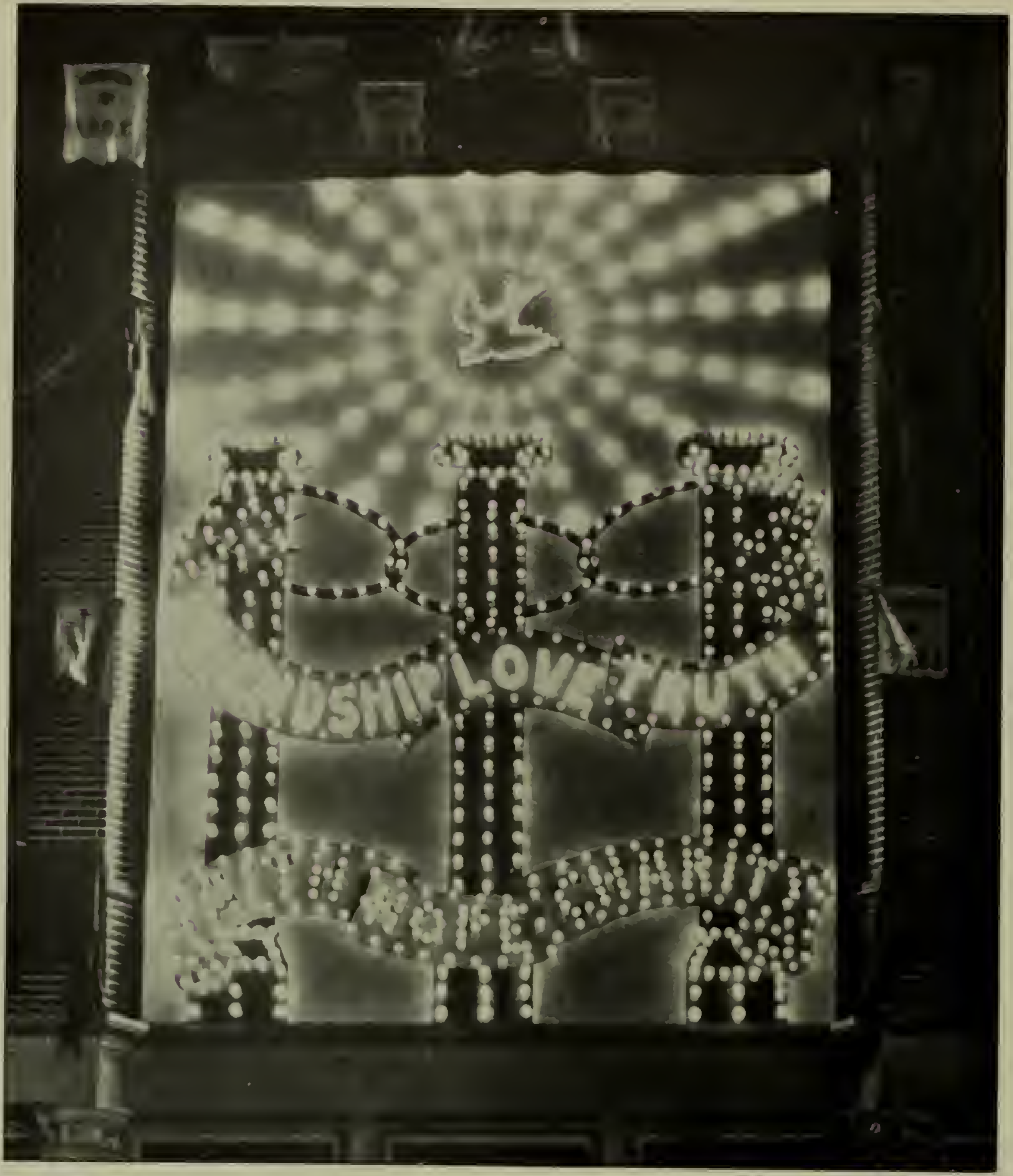
Recent expositions have been made particularly attractive on account of the electrical illumination at night, for, while the spectacular displays made by the fountains have been extremely picturesque, the illumination of the buildings and grounds have formed a spectacle fully as interesting. The proximity of Niagara Falls and the convenience of current supply caused the electrical display at the Pan-American Exposition to be by far the most attractive feature of this fair.

Those who were so fortunate to witness it, will never forget the effect produced when the myriad of lights were gradually turned on at dusk. The expositions which preceded and succeeded the Pan-American were actually inferior to it in this respect. The Lewis and Clark Exposition at Portland was also notable for the beauty of the electrical designs. While the system of lighting was not so elaborate as at Buffalo and St. Louis, much taste was displayed in the arrangement of the series of lamps.

One of the most prominent features of the Lewis and Clark Exposition were the towers here and there upon the grounds, as well as upon the bridge across the lagoon, the towers supporting clusters of lamps arranged in the form of pendants, each light being shaded by a globe of frosted glass. The spectacle produced was by far the most fascinating feature connected with the exposition. Each of the principal buildings was, of course, outlined by a series of lamps, including the mammoth log house, the illumination from which also lighted up the trees and foliage surrounding it.

Another way in which the electrical current may be said to be utilized for amusement is in illuminating cities during conventions and other events, when throngs of visitors are present. The accompanying illustrations give an excellent idea of how a community may be made attractive after nightfall. One of the principal forms of attraction is the construction of what is called the "Court of Honour." From a dome or bell outlined in incandescent lamps, festoons of the lamps extend to columns of wood or staff arranged in a semicircle or rectangle. The dome is supported by cables stretched from side to side of the thoroughfare, and the current is transmitted from the municipal or other lighting plant.

One of the illustrations show a court which was erected in Baltimore



AN ELECTRICAL "ODD FELLOWS" EMBLEM USED DURING A BALTIMORE CONVENTION

in honour of the Elks' convention. It was placed in Monument Square, and formed a most beautiful spectacle after nightfall, the court house and other prominent buildings being plainly reflected in the light.

Streets can be readily illuminated by the construction of ornamental arches here and there, studded with incandescent lamps, and by festoons of lamps stretched on wire from side to side. The ornamentation of building fronts by means of the electric current is by no means new or novel, and has become as much of a necessity for advertising purposes as the theatrical sign. Where a city is illuminated especially for gala purposes, these electrical advertisements contribute not a little to the spectacular beauty.

The new Cunard liner "Mauritania," now building, will have two electric passenger elevators, two for baggage, and six smaller electric elevators for mails and the like.

Annual Report of the General Electric Company

THE annual report of the General Electric Company for the year ended January 31, 1905, showed that the sales for the year were about $4,000,000, or 10 per cent. greater than those of the previous year. The profits, including $173,389 from securities sold and $798,539 from royalties, after deducting all patent, general and miscellaneous expenses and allowances for depreciation, and $1,838,362, expended for factory plants and machinery, were $7,319,160. There were paid in dividends $3,861,062, and $1,000,000 were written off the patent account, leaving a surplus of $2,458,098. The total surplus was thereby increased to $12,027,295.

During the year the company received orders for railway motors of the aggregate capacity of 750,000 horse-power, and 4025 cars were equipped with Sprague-General Electric train control, as against 2997 in the previous year.

Despite an increase in the capacity for the production of turbines, it was impossible to keep pace with orders. There were shipped 214 to domestic customers and 44 abroad. The single-phase alternating-current railway apparatus, first used in August, 1904, was sold to five large traction companies. The company also delivered the first of an order for thirty-five 100-ton electric locomotives for the New York Central.

The company's employees increased from 18,000 to 22,500. New buildings, with floor space of 33,000 feet, were erected at Schenectady, and about 108,000 square feet were added to the plant at Lynn, Mass. Buildings are in course of construction at both places. The balance sheet is as follows:—

ASSETS.			
Cash			$6,356,093.77
Stocks and bonds		$19,104,539.30	
Real estate (other than factory plants)		359,013.86	
Notes and accounts receivable		16,287,018.01	
Work in progress		2,496,205.78	
		$38,246,776.95	
Merchandise inventories:			
At factories	$14,983,710.46		
At general and local offices	1,782,678.47		
Consignments	155,901.91		
		16,922,290.84	
			55,169,067.79
Factory plants		8,000,000.00	
Patents, franchises and good will		1,000,000.00	
			9,000,000.00
			$70,525,161.56
LIABILITIES.			
3½% gold coupon debentures		$2,047,000.00	
5% gold coupon debentures		55,000.00	
Accrued interest on debentures		458.33	
Accounts payable		2,106,863.89	
Unclaimed dividends		1,794.25	
			$4,211,116.47
Capital stock			54,286,750.00
Surplus			12,027,295.09
Total			$70,525,161.56

On April 2, 1906, expired the patent granted to Charles M. Hall in April, 1899, for an electrical process for making aluminum. It consists in the use of an electrolytic composed of cryolite as a solvent for beauxite, and one of its special features of value is that it possesses the important property of being easily fusible. Charles M. Hall is connected with the Pittsburg Reduction Company, of Niagara Falls, and the patent has given the Pittsburg Reduction Company a practical monopoly of the manufacture of aluminum in the country. While the Hall patent has expired, it is stated in Niagara Falls that the method of operation of the Pittsburg Reduction Company is still protected by the patent granted to Mr. Bradley, one of the early pioneer workers in the aluminum field, and which does not expire until February 2, 1909.

The Corrosion of Iron by Acids

By C. F. Burgess and S. G. Engle

A Paper Read at the Ninth General Meeting of the American Electrochemical Society

IT is well known that the rate at which iron corrodes or combines chemically with its surrounding medium depends upon various factors, including temperature, pressure, nature of corroding agent as to chemical composition and purity, speed with which the resulting compound is removed from the corroding surface, and the physical and chemical state of the iron itself.

Many features of scientific and technical interest have been pointed out by investigators of this subject, and there has been produced a large mass of scattered and fragmentary information, ranging from the solvent action of various acids on the individual metallographic constituents of iron alloys to the observations of the pickler that the acid which he obtains from one manufacturer is satisfactory while that which he obtains under the same name from another manufacturer is worthless.

It is the purpose to record here the results of a few observations made in connection with a more extensive study of electrolytic iron under a grant from the Carnegie Institution, of Washington. These observations deal mainly with the rapidity of solution of several grades of iron in dilute acids.

The corroding mediums employed were normal solutions of sulphuric and hydrochloric acids, distilled water and chemically pure acids being used. The solutions were kept at room temperature (about 22 deg. C.) and during corrosion, additions of acid were made to keep the solutions at a nearly constant content of free acid.

The several grades of iron which were compared included electrolytic iron which had been deposited from a mixed sulphate and chloride solution; the same iron which had been heated to about 1000 deg. C. and allowed to cool slowly; soft sheet iron, low in carbon, such as is used in the manufacture of transformer plates, and which is herein designated as a transformer iron; a temper steel, such as is used in the manufacture of knife blades, and an ordinary grade of cast iron.

Sample plates were prepared from these materials, each having about 5 square inches of surface area. The surfaces, prior to immersion in the acids, were ground smooth on an emery wheel to give uniformity and freedom from scale and impurity. The samples were weighed and immersed for measured periods in the acid solutions, removed therefrom and dipped into dilute sodium hydrate, rinsed in hot water, dried and weighed.

The specimens were suspended in the solutions by means of a grooved stirrup of hard rubber, and they were arranged in such manner that the separate plates did not come into contact with each other.

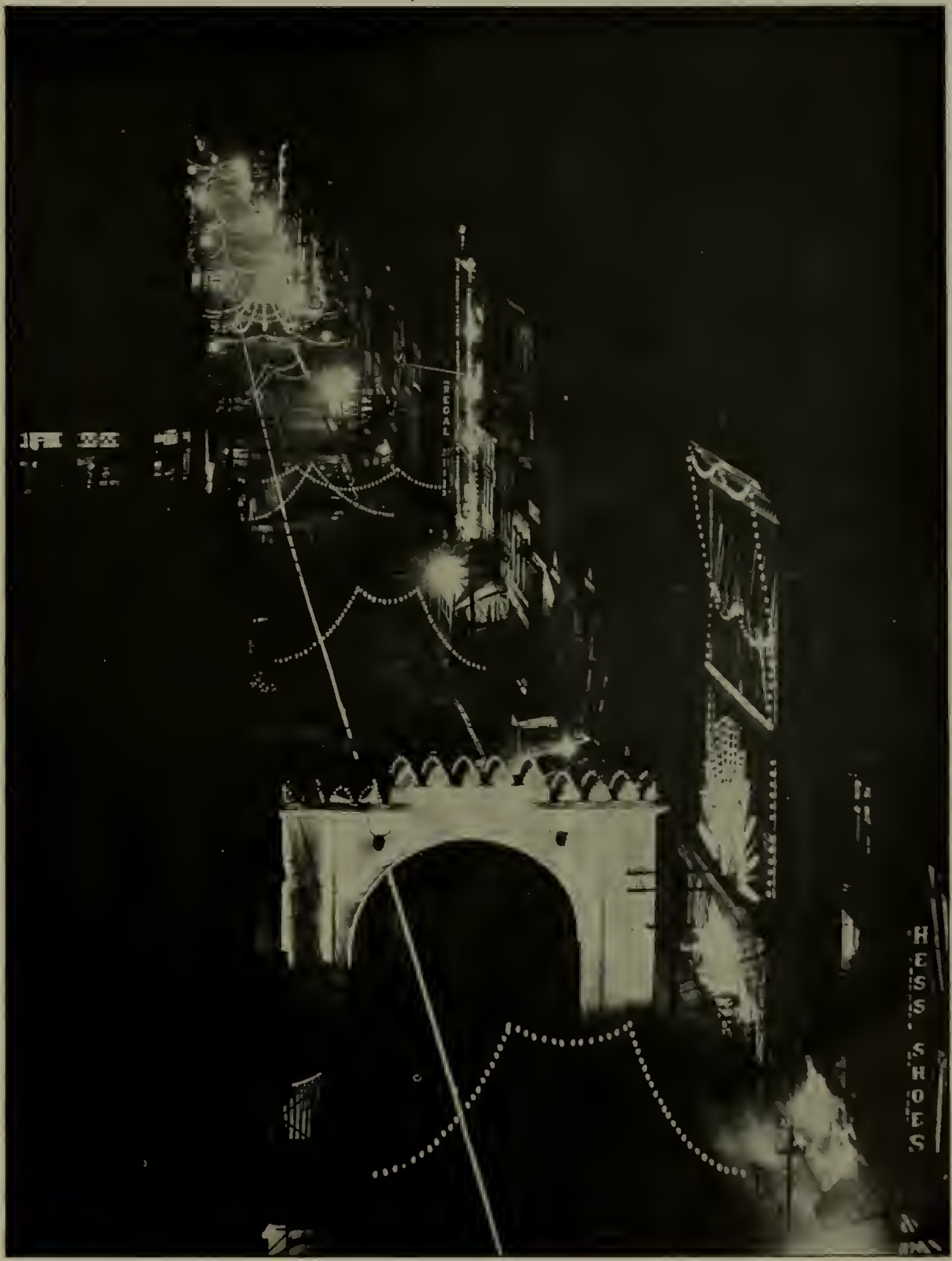
TABLE I.

Loss in grams per square inch per hour. Solution-normal H_2SO_4

Hour	1st	2d	3d	4th	5th*	6th
Electrolytic	.0319	.2933	.4029	.4098	.5137	.4805
Electro. heated	.0053	.0162	.0088	.0112	.0063	.0078
Cast iron	.0758	.0947	.0737	.0373	.0335	.0525
Steel	.0163	.0086	.0703	.1181	.1135	.0974
Transformer iron	.0090	.0136	.0028	.0074	.0084	.0081

Hour	7th	8th	9th†	10th	11th	Average
Electrolytic	.4284	.4221	....	....	....	.3728
Electro, heated	.0071	.0067	.0684	.0120	.0105	.0091
Cast iron	.0638	.0581	.0668	.0677	.0842	.0643
Steel	.1182	.1371	.1344	.1153	.1396	.0971
Transformer iron	.0097	.0104	.0107	.0112	.0119	.0093

* Added 3. lg. H_2SO_4 per liter to replace that consumed by iron.
† Added 4.6 lg. H_2SO_4 per liter to replace that consumed by iron.



A STREET BRILLIANTLY ILLUMINATED FOR A CONVENTION OF A FRATERNAL ORDER.
SEE PAGE 447

AN ELECTRICAL MASONIC EMBLEM ON THE MASONIC TEMPLE IN BALTIMORE. SEE PAGE 447

Table I. shows the relative rates of corrosion of the five samples of iron for successive hours during the progress of the test. The striking facts which are brought out numerically in this table, and graphically in the curves plotted in Fig. 1 are that electrolytic iron in the condition which it possessed just as it was taken from the tanks, corroded at a far greater rate than did the other samples, about six times as rapidly as the cast-iron, four times as rapidly as the steel, and nearly forty times as rapidly as the transformer iron. It is also shown that the heat treatment to which the electrolytic iron was subjected conferred upon it the property of resisting corrosion to a great degree, the heated electrolytic iron dissolving at a hardly appreciable rate as compared with the samples which had been unheated.

As indicated in the table, the specimen of unheated electrolytic iron was removed from the test at the end of the eighth hour, this having been done on account of its having been practically consumed. That this sample was acted upon far more vigorously than were the others was shown by the rapid evolution of hydrogen which proceeded from it.

In removing the test specimens from the solution at the end of each hour, a certain amount of loosened material became detached, except in the case of the electrolytic samples, which remained smooth and bright; and to avoid any irregularities in

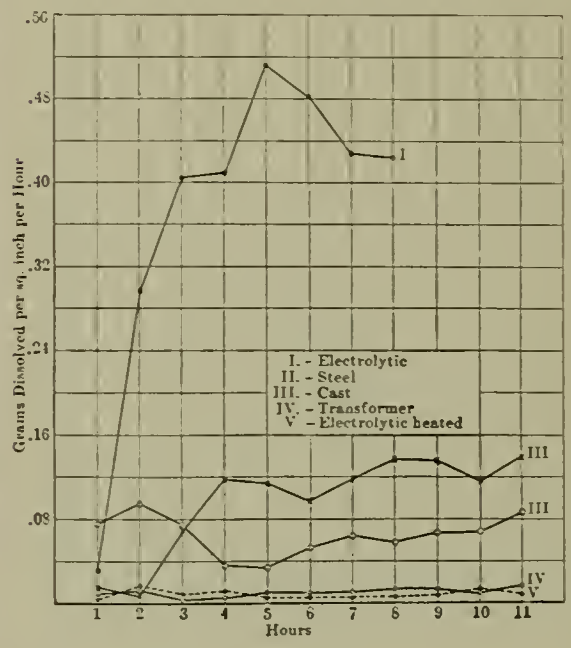


FIG. 1

the weight determinations which might result from this, duplicate samples were again placed in normal solutions of the acids and left for seventeen hours without disturbing. As regards rates of corrosion in this test, the various grades of iron held the same relations as they did in the first run, while in the hydrochloric acid, the steel showed the least tendency to dissolve. The results of this run are given in Table II. In this table are given also the rates at which zinc of the grades known as "chemically pure" and "commercial" were dissolved in sulphuric acid.

TABLE II.

Loss in grams per square inch per hour on a 17-hour run

	In Normal H_2SO_4 Gram	In Normal HCl Gram
Electrolytic	.4575	.2146
Electro. heated	.0209	.0083
Steel	.0946	.0026
Cast iron	.0796	.1058
Transformer iron	.0279	.0095
Zinc, c. p.	.1410	.....
Zinc, commercial	.2607	....

It is a well-known fact that pure zinc dissolves in acids much more reluctantly than does the less pure metal, this phenomenon commonly being attributed to the influence of the more numerous galvanic couples which are produced by the larger number of particles of impurity in the latter grade of zinc. Reasoning

from this analogy, it would be natural to expect that electrolytic iron, having a high degree of purity, as compared with the other samples, would dissolve at a much slower rate.

The striking evidence that this is not the case is shown by the foregoing data and curves, and the remarkable chemical activity of the electrolytic iron calls for explanation. From the fact that electrolytic iron contains considerable quantities of hydrogen in an occluded or combined condition, it might be suggested that we should look to the influence of this element as the cause of this phenomenon.

This view has for its support the observation that upon heating the iron to a red heat, and thus driving off most of the hydrogen, the corrodibility is decreased in a remarkable degree.

It is the belief of the writers, however, that if hydrogen produces an influence, it does so only indirectly, and that the crystalline structure should be taken into account. Electrolytic iron, deposited from its electrolyte, assumes a marked crystalline structure, as shown plainly not only by the microscope, but also to the unaided eye. The nature of this structure, as shown on fracture, varies from needle-and-fern-like forms to a more dense and compact condition, depending upon current density, composition of solution, and other factors. These structures disappear upon heating to a bright yellow heat, such as was used to drive off the hydrogen, and an examination by the microscope shows the iron to assume the form which is characteristic of that of a pure wrought iron, typical ferrite grains being plainly apparent. Incidentally, it might be noted that this change in structure is accompanied by marked alteration in the physical properties, the iron changing from a hard and extremely brittle condition to a soft, tough state.

To determine whether the crystalline structure of electrolytic iron has an influence on the rate of dissolving acid solution, two samples were chosen, one of which was coarsely crystalline, deposited from a ferrous ammonium sulphate solution with a small amount of ferrous chloride, and the other deposited from a solution containing a larger percentage of chloride and which gave a much more dense and fibrous deposit. The results are given in Table III.

At the Bethlehem meeting of the American Electrochemical Society, a paper was presented, dealing with the presence of arsenic in sulphuric

TABLE III.

Loss in grams per square inch per hour on a 17-hour run. Normal H_2SO_4

	Gram
Electrolytic iron, coarsely crystalline	.4805
Same iron heated	.0685
Electrolytic iron, more dense	.3291
Same iron heated	.0225

acid as influencing the activity of the acid on iron. The various samples herein described were subjected to a normal sulphuric acid solution which contained a small amount of arsenic, and after twenty-two hours, the amount of iron dissolved from all of the specimens was so small as to be undetected, the electrolytic, as well as the other forms of iron, becoming practically passive in the arsenical solution. The explanation which has been offered for this phenomenon is that the iron receives, by contact with the solution, an extremely thin coat of arsenic which resists the action of the acid and protects the underlying metal. While such coating was not detected by the eye, the presence of arsenic was shown by the following test:—A strip of pure iron which had become passive by the action of arsenic in sulphuric acid, was removed from the solution and washed in running water for several hours. It was then put into a Marsh's apparatus and acted upon by a strong solution of arsenic-free sulphuric acid. The gases which were evolved were delivered through a solution of silver nitrate, soon producing the characteristic black metallic silver precipitate, caused by the presence of the arseniureted hydrogen gas. A similar sample of iron which had not been subjected to the arsenical solution produced no black precipitate.

From the fact that an extremely small amount of arsenic in the presence of iron can enable that iron to resist a corroding influence as strong as that exerted by sulphuric acid, it is natural to infer that this element

MONUMENT SQUARE IN BALTIMORE WITH ANOTHER VIEW OF THE "COURT OF HONOUR"
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might be employed in protecting iron from atmospheric and other corroding influences.

In studying the influence of arsenic on steel, Mr. J. E. Stead found that arsenic, instead of being the enemy of the steel maker, as has been commonly assumed, might, in fact, under certain conditions, be his friend, in imparting desirable properties to low carbon steels. Among other observations, he noted that in iron wires containing from 0.11 per cent. to 0.21 per cent. of arsenic and carbon from 0.10 per cent. to 0.4 per cent., the corrosion by sea water was materially lower than in wires of similar composition, but with lower amounts of arsenic. He says:—"Oxidation is retarded by the presence of small quantities of arsenic."*

We have not found references to additional work along this line, and in view of the great importance of continued study on the corrosion of iron, and the possibility of using arsenic as a means of imparting greater durability, a further study of the influence of this element seems warranted.

TABLE IV.

Single potentials of metals. (Calomel electrode = —.56) at 24 degs. C.

	n. H_2SO_4 Volt	n. $FeSO_4$ (neutral) Volt	n. H_2SO_4 (with arsenic) Volt
Electrolytic iron	.0476	.1164	—.073
Electrolytic iron, heated	.0270	.1056	.146
Transformer iron	—.0183	.1028	—.156
Cast iron	—.045	.0518	—.115
Steel	—.062	.0303	—.136

To determine whether electric potentials of iron, with its corroding electrolyte, has any relation to its tendency to corrode, the contact potentials of the various specimens used in this investigation were measured by the use of the mormal calomel electrode, the value of which is assumed as —.56-volt. The results of these observations are given in Table IV. The electrolytic iron is placed at the head of the list, according to these measurements, as it is also at the head of the list arranged according to the rate of solution. On the other hand, the arrangement of the other samples is not similar, and, consequently, we cannot assume that the single potential is anything more than a rough guide in suggesting tendency to corrode. It is interesting, perhaps, to note that all the specimens assumed a more electronegative potential in the arsenical solutions than in the others.

CONCLUSIONS

That the rate at which an acid dissolves iron depends largely upon the elements with which the iron is associated does not need the confirmatory data here given to establish its truth. It is well known that the various metallographic constituents of iron and its alloys resist in differing degrees the attack of acids, and, therefore, different grades of iron show differences of durability.

That the percentage of purity is not the controlling factor is here shown by the observations that the heated and unheated specimens of electrolytic iron, essentially the same as far as chemical composition is concerned, exhibit the widest possible variations in rate of solution.

The crystalline or granular structure of iron seems to influence rates of corrosion in a marked degree.

The rapidity with which unheated electrolytic iron liberates hydrogen in a dilute acid solution suggests a useful application of this material in the production of pure hydrogen by replacing zinc, which is now commonly used. From Table I. it is observed that from equal surfaces of exposed metal, electrolytic iron liberates hydrogen about four times as rapidly as does pure zinc, and twice as rapidly as the commercial grade.

Another advantage in the use of electrolytic iron in hydrogen generation lies in its higher purity and the consequent increased purity of the resulting gas, as compared with that which is obtained from zinc. One pound of iron produces 16 per cent. more hydrogen than does one pound of zinc, and if a sufficient demand for iron for this purpose should arise, it could be supplied at a cost materially less than that of zinc.

Traces of arsenic are shown to exert such a marked influence in protecting iron from the corroding action of acids that the employment of this element for protection against ordinary corrosion appears worthy of further investigation.

While the measurement of electric potentials of iron against corroding agents seems to afford some indication as to the rapidity with which it will become attacked, it does not seem possible to establish definite relations between electric potentials and corrodibility.

* Journal of the Iron and Steel Institute, 1, page 96 (1895).

A telephone line is now being built for the Union Pacific Railway from Chicago to San Francisco.

Edison in Fiction

ALTHOUGH it is not usual for authors to introduce in fiction the names of prominent living persons, Robert Barr has done so in his new novel, "The Triumphs of Eugene Valmont." The hero of the novel is Valmont, a great French detective, who meets Thomas A. Edison in a hotel in Paris. Here Edison tells of his invention of the incandescent electric lamp as follows:—

"It was not an invention, but a discovery. We knew what we wanted, a carbonized tissue which would withstand the electric current in a vacuum for, say, a thousand hours. If no such tissue existed, then the incandescent light as we know it was not possible. My assistants started out to find this tissue, and we simply carbonized everything we could lay our hands on, and ran the current through it in a vacuum. At last we struck the right thing, as we were bound to do if we kept on long enough, and if the thing existed. Patience and hard work will overcome any obstacle."

Valmont was so impressed by the last sentence in Edison's story that he used it as a text whenever he came across a difficult problem.

Telephones for Forest Reserves

FOR the better protection of the forest reserves, says "Forestry and Irrigation," the Forest Service, in co-operation with the Weather Bureau, will install a system of telephone lines and stations on them as rapidly as possible. The first system will be installed on the Big Horn Forest Reserve, in Wyoming. This telephone service will enable the forest rangers to notify one another, without delay, when forest fires break out. In so large an area as the Big Horn Forest Reserve, which comprises 1,151,680 acres, the value of rapid communication is obvious, and there can be no doubt that the elimination of delay will result in a striking improvement in the control of forest fires.

A new company has been formed in Madrid, Spain, called the Sociedad General de Transportes Eléctricos, which will exploit the waterfalls of the Duero River, near the Portuguese frontier, and which will supply a large number of places, including Oporto, with electricity for power purposes. The largest fall is about 470 feet, and is estimated to produce 40,000 horse-power.

The Depreciation of Electrical Properties

By G. W. BISSELL

A Paper Read at the Recent Meeting of the Iowa Electrical Association

As a preliminary to the preparation of this paper the writer sent to each member of the association a letter propounding and asking replies to the following inquiries:—

1. In computing the total cost of your output, do you make allowance for depreciation?

2. If the answer to No. 1 is affirmative, how much depreciation do you charge off, and how do you arrive at this amount?

3. How do you invest your sinking fund?

Twenty replies were received. Three answered questions 1 and 3 in the negative, without explanation or other sign of interest in the matter, and, of course, gave no answer to question No. 2.

Four members answered question No. 1 in the negative, but explained that circumstances, such as pressure for dividends, prevented the practice, or that extensive renewals of deteriorated property had prevented allowance for depreciation, or that the plant was not yet old enough to be affected by depreciation; but all four evidently appreciated the importance of the subject.

Two members took issue against the recognition of depreciation as an account to be considered in making a true book showing of the property. Attention will be called to these arguments later.

One member answered question No. 1 in the affirmative and No 3 in the negative, and evidently confused depreciation and maintenance.

The remainder, ten in number, gave affirmative and more or less complete answers to the three inquiries, and quotations from the letters are here presented.

(1) "We set aside about 5 per cent. of gross investment each year for maintenance of property."

(2) "We use the replacement value of the plant equipment as a base on which to figure depreciation. * * * The fund derived from these amounts is deposited in the bank as a time deposit and draws interest. It can only be withdrawn by consent of our board of directors. All amounts realized from sale of replaced machinery, scrap, wire, or any part of our equipment, is credited to this account. Sinking fund is for bond redemption only."

(3) "Upon the actual cost of our plant we figure a depreciation of 8 per cent., and invest the amount where we can find and receive the best interest rate."

(4) "Charges of 8 per cent. annually, investing not to exceed one-half in improvements and the balance in the bank at 4 per cent. per annum for replacements."

(5) "We figure 6 per cent for depreciation in computing the cost of current, but have never been able to create a sinking fund to take care of the item. We consider 6 per cent. a low figure."

(6) "We charge 5 per cent. of our total investment each year for depreciation. Ten years' experience shows that this is not enough, and hereafter the charge will be 7 per cent.

"Depreciation is the one thing that makes electric lighting in a small town a poor business."

(7) "As a rule, electric installations are without sufficient capital. They soon find themselves face to face with the proposition of providing for their extensions and depreciation, and at the same time meet the expectations of the stockholders for dividends. It has been our custom to put sufficient money into the plant each year in the way of repairs to maintain its value. The objection to this plan of providing for depreciation is that it is not uniform. One year we have little or no repairs, while next year the repairs are excessive.

"In the present state of business I should think a fair allowance for depreciation would be from 8 to 10 per cent. on the cost of construction. While it is true that electric apparatus as built to-day perhaps has a life of more than ten years, still in the readjustment of things occasioned by the growth and development of the business and the growth and development of appliances, our past experience will indicate that we will rarely ever use a piece of machinery more than ten years.

"We believe that a fixed per cent. on original cost should be placed in the sinking fund each year to provide for depreciation, and that this sinking fund should be invested to the best possible advantage; but we think you will find very few companies in Iowa providing a sinking fund.

"It is not wise for a manager to overlook this item, because it is something that must be provided for, and while he may be able to evade it for a few years, it will finally present itself in an aggravated form, and there is no escape."

(8) "We had no bonded indebtedness until May, 1904, when a mortgage of $650,000 was given to secure a bond issue in like amount. The entire proceeds from the sale of bonds, with an additional $100,000 advanced by the stockholders on the company's note, was put into the reconstruction of the property. The physical condition of the plant previous to the reconstruction was exceedingly bad, and the entire income was required for repairs and operation, leaving no surplus for dividends or other purposes.

"The following provision is made for a sinking fund:—

"'A sinking fund shall be created and maintained during the uncancelled existence of this mortgage for the payment, in part, of the principal of the bonds hereby secured, and shall consist of the payment in the sum of $15,000 on the 30th day of April in each year on and after April 30, 1906, by the company to the trustees, which annual payment company agrees to make to the trustees.

"'It is further provided that the trustees shall hold the annual payments until the disbursement thereof, allowing the company interest thereon, this interest to be added to the sinking fund annually. The money so accumulating shall be used from time to time for the purchase by the trustees of the bonds at a price not to exceed 5 per cent. par; the bonds so purchased shall be cancelled

and delivered to the company.

"You will note that the annual payment of the $15,000 is not effective until 1908. We are, with the commencement of the current year, however, charging off 20 per cent. of the gross receipts each month to depreciation and maintenance. From this amount we subtract the actual maintenance cost for the month, the balance being charged to depreciation.

"In my opinion, there are few companies in the State which have a broad provision for depreciation and sinking fund. This provision should undoubtedly be made, otherwise, at the expiration of the life of the bond issue, the property will be sadly depreciated in value and no funds in hand to put it in the same physical condition as at the issuance of the bonds.

"Capital is becoming more insistent that sinking fund provisions be made, although the majority of bond issues now in effect carry no such provision."

The above quotations and other information contained in the letters of the members who believe in and practice the recognition of depreciation as a factor in central station finance, are from cities of from 3000 to 50,000 population widely distributed over the State. Evidently some plant managers are thinking hard over the question.

Reference has been made to members presenting arguments against depreciation as an element of productive cost. One member writes:—"In regard to depreciation, I will say that I differ from most people on this subject. We do not charge off any depreciation. When any part of our machinery gives out, we repair it or replace it with new and charge it to expense. If a pole is decayed and unsafe, we replace it with a new pole and charge it to expense, and so on through the entire system. In this way we pay for our depreciation as it comes. We classify our accounts to a certain extent. We have an account for meters, transformers, coal, repairs to boilers, station supplies, equipment, etc. Meter repairs are charged to expense, and new additional meters are charged up to meters. A new meter to replace an old one is charged to expense, and similarly with transformers, etc. Annually, or as often as desired, we can balance up our accounts and see how we stand."

But he concludes with this statement:—"If a plant is making more than a fair dividend, I would set aside some of it for a surplus and put it in a good bank at interest. Then, in case of a breakdown or extension of plant, there would be some ready money."

It would seem as though the last statement qualifies materially the non-belief in depreciation accounts, and that the writer really would charge off depreciation if his business would pay him well enough to enable him to do so.

Another member writes:—"If a plant is earning sufficient money to take care of the maintenance, which must include all replacements and renewals and interest on the investment, and has anything left, it would seem better to pay it to the stockholders in extra dividends than to run the risk of holding it in a sinking fund. Keeping the fund safely would be a problem. Keeping it profitably invested would be still more of one, but when it is paid to the stockholders as it accumulates all this is avoided."

To this view of the case there might be presented the question:—How will these same stockholders feel if extraordinary expense, such as replacing obsolete equipment, necessitates an assessment, and how much worse will their heirs or assigns feel who have not directly received the previous large dividends? Is it not better to anticipate such a contingency by having a fund to meet it?

The object of depreciation as a book-account is, according to Ewing Matheson, so to treat the nominal capital on the books that it shall represent as nearly as possible the real value. Theoretically, the most equitable method of doing this, if feasible, would be to revalue everything at stated intervals, and to write off whatever loss might be thus revealed without regard to any prescribed rate of depreciation.

"This plan, if strictly carried out, has in practice some disadvantages. The two leading considerations in such an appraisement are generally the condition of the property and its earning power. In both these respects there may be absolutely no sign of deterioration; a machine may appear, and for all practical purposes be, as good as new, and may show proof of it by actual earnings. Yet none the less its working life is shortened year by year, and unless some provision is made for replacement a severe loss will fall on the future. And if, recognizing this, something is written off the value, though no alteration is apparent, then a depreciation rate is in fact applied.*

* The Depreciating of Factories—Matheson, p. 24.

"The question of depreciation cannot be separated from that of maintenance, and in theory one may be said to balance the other. In practice it is only in certain cases that this can be acted on. In any particular building, machine, or appurtenance, decay or wear of some sort must take place in the course of time, and repairs, in order to compensate fully for the decline in value, must take the form of renewal.

"This being the case, the absolute replacement of some portion of the plant every year may maintain an average aggregate value. In only two kinds or classes of plant, however, can such an exact balancing of loss by repairs and renewals be ventured upon: one, where the plant wears out so quickly as to need complete replacement at short intervals, and in a second class, that of undertakings so large and permanent as to afford a wide annual average of deterioration and renewal over the whole plant."

In short, depreciation account provides insurance against those losses in value which cannot be met by current repairs and minor renewals, which are intangible until some future time when the equipment is found to be unsafe or obsolete and inefficient in view of advance in the state of the art.

Depreciation may be based upon a uniform rate for all parts of a property. This is an easy way, as far as figuring is concerned, but requires rare judgment in its application to so complex an undertaking as an electrical property.

Depreciation may be based upon an average rate of the several rates of depreciation proper to the component parts of the plant. The correct method of finding the depreciation rate is exemplified in the following problems:—

Suppose a power plant to consist of:—

Buildings and chimney worth $25,000, having an estimated useful life of 50 years.

Boilers and auxiliaries, worth $20,000, having an estimated useful life of 15 years.

Engines and generators worth $30,000, having an estimated useful life of 12 years.

Switchboard worth $2500, useful life 10 years.

The depreciation period may be assumed at 50 years.

The depreciation is sometimes obtained as follows:—

Buildings	$25,000 × 1-50	$500.00
Boilers	20,000 × 1-15	1,333.33
Engines	30,000 × 1-12	2,500.00
Switch-board	2,500 × 1-10	250.00
	$77,500	$4,583.33

$4,583.33 ÷ $77 500 = 5.9 per cent.

which result is correct if the annual amount of $4,583.33 charged to depreciation draws no interest.

Another method is to obtain the average life of the whole plant, as follows:—

$$\begin{array}{rcr} \$25{,}000 \times 50 = & & \$1{,}250{,}000 \\ 20{,}000 \times 15 = & & 300{,}000 \\ 30{,}000 \times 12 = & & 360{,}000 \\ 2{,}500 \times 10 = & & 25{,}000 \\ \hline \$77{,}500 & & \$1{,}935{,}000 \end{array}$$

$$\$1{,}935{,}000 \div \$77{,}500 = 25 \text{ years}$$

from which the rate of depreciation would be 4 per cent. and the annual charges would be $3100. This is too small, as appears from Table I.:—

TABLE I

Life Years	Value of Part	Times to be Renewed in 50 Years	Total Renewal Expense in 25 Years	Years	Dollars, Years
50	$25,000	1	$25,000	50	$1,250,060
15	20,000	$3\frac{1}{3}$	$66{,}666\frac{2}{3}$	15	1,000,000
12	30,000	$4\frac{1}{6}$	125,000	13	1,500,000
10	2,500	5	12,500	10	125,000
	$77,500		$$229{,}166\frac{2}{3}$		$3,875,000

$\$3{,}875{,}000 \div 229{,}166\frac{2}{3} = 16.9$ years.
$77{,}500 \div 16.9 = \$4{,}583 = 5.9$ per cent.
$229{,}166\frac{2}{3} \div 50 = 4{,}583 = 5.9$ per cent.

It is probable that the energetic plant manager would keep his depreciation allowance or sinking fund invested. Suppose that it is possible to safely count on 3 per cent. compound interest on the continual contributions to the sinking fund in the above assumed problem, the annual charge to depreciation would be obtained as folows:—

For each part of the plant, find what sum at 3 per cent. will amount to the redemption value in the term of years estimated as the life of the part.

Thus, for the buildings worth $25,000 and estimated to last 50 years, interest tables (see Kent's Hand-book, 5th Edition, p. 16) show that an annual payment of $8.87 at 3 per cent. compound interest will in 50 years amount to $1000. Therefore, $221.75 so invested will furnish the sum for replacing the building at the end of 50 years.

For the whole plant the several depreciation items computed in this way are presented in Table II.:—

TABLE II

Life	Value of Part	Annuity per $1000 at 3%	Annuity for Actual Value	Same at 4%	Same at No Interest
50	$25,000	$8.87	$221.75	163.75	$500.00
15	20,000	53.77	1,075.40	998.80	1,333.00
12	30,000	70.46	2,113.80	1,996.50	2,500.00
10	2,500	87.24	218.10	208.25	250.00
Total annual charge..			$3.629.05	$3,367.35	$4,583.00

From this it appears that the total annual charge for depreciation is $3,629.05, as compared with $4583 where the sinking fund is non-earning.

The rate of interest in any given case should be very conservative in order to cover errors of judgment in overestimating the natural life of the part or to provide for premature renewal due to extraordinary causes. In case the parts of the plant last longer than was expected, the accumulated depreciation charges can be held stationary until such part does need renewal and the usual annual charge used in some other way, —to increase dividends or surplus or to offset errors in the other direction as to depreciation in other parts of the plant.

As to the method of investment of the depreciation sinking fund, there are several avenues for ready money. Improvements in the plant or extensions are legitimate if they will pay the interest on which the annuity is based. Otherwise they are not. A line ten blocks long to supply lights to one or two houses at the end would not be remunerative enough for this purpose. It should be constantly borne in mind that the depreciation allowances are each specific, and their use for other purposes should not be tolerated. Repairs and maintenance must be regarded as distinct from depreciation sinking fund and otherwise provided for.

It should not be understood from the above discussion that the rate of depreciation is assigned once and for all at the beginning of an enterprise and not subject to modifications. The point to be emphasized and driven home is that the fact of depreciation is real and must be met at the outset, or later calculations and business transactions will be very disappointing to the man or corporation whose money is at stake.

As to the life to be assigned to the various parts of electrical properties, there are "many men of many minds."

Dawson, in his "Engineering and Electric Traction Pocket-Book," page 1265, suggests:—

Buildings, 50 to 100 years.
Water turbines, 11 to 14 years.
Boilers, 10 to $12\frac{1}{2}$ years.
Engines and generators, belted, 10 to 20 years.
Belts, 3 to 4 years.
Large, slow-speed steam engines, 15 to 25 years.
Ditto, direct-connected, $12\frac{1}{2}$ to 25 years.
Stationary transformers, 15 to 20 years.
Storage batteries, 9 to 11 years.
Trolley line, $12\frac{1}{2}$ to 25 years.
Feeder cables, 20 to 35 years.
Meters, 10 to $12\frac{1}{2}$ years.
Cars, 15 to 25 years.
Motors, $12\frac{1}{2}$ to 20 years.
Rotaries, 10 to $12\frac{1}{2}$ years.
Spare parts, 50 to 75 years.
Track work, 7 to 13 years.
Binding, 10 to 16 years.
Sundries, 16 to 25 years.

On some of these items the figures are too high for average American practice, because we do more temporary work than Europeans and make our equipment work harder.

Some members of this association have given the following:—

Buildings, 25 years,—the franchise life, 33 years, 50 years.
Boilers, grates, etc., 14 to 15 years.
Piping, 14 to 15 years.
Pumps, 10 years.
Engine condensers, $12\frac{1}{2}$ years.
Foundations, $12\frac{1}{2}$ years.
Station wiring, $12\frac{1}{2}$ years.
Switchboard, 10 years.
Poles, cross-arms, $12\frac{1}{2}$ to 10 years.
Wire, 25 years.
Arc lamps, 8 years.
Meters, 10 years.
Transformers, $12\frac{1}{2}$ years.
Whole plant, 20 years, $16\frac{2}{3}$ years, 14 years, $12\frac{1}{2}$ years.

Real estate is supposed not to depreciate.

Why Europe Lags in Telephone Service

IN a series of articles on "Commercial Telephony," written by Herbert Laws Webb for "The London Times" Engineering Supplement, are given a number of reasons why Europe lags behind America in telephone service.

The principal reason given is the difference of the attitude of the public—and of the representatives of the public—of the two continents toward the telephone service. In America the telephone service has been treated as a friend, or as a promising youngster capable of effecting vast improvement in the conduct of affairs. No artificial restrictions have been imposed to hinder its development, and neither the telephone manager nor the public has put the question of cost before the question of efficiency.

In Europe the telephone service has never been treated as a legitimate business enterprise and has never had a fair field. From the very beginning it has been treated as a mere offshoot of the telegraph—which it is not—and it has occupied the position of Cinderella in the family of methods of communication placed under government control. As a result, not only have all sorts of harassing restrictions inseparable from a bureaucratic control been brought to bear, but telephony as a science, telephone engineering as a specialty, and telephone administration as a distinct branch of organized effort have been neglected.

THE ELECTRICAL AGE

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Leading Articles

The Electric Smelting of Iron Ores

THE recent experiments carried on in Canada in the electric smelting of iron ores appear to have demonstrated that in a certain field the electric furnace is superior to the blast furnace. The situation seems to be somewhat akin to that of alternating and direct-current motors or of steam traction and that with electricity. The one cannot entirely replace the other, but is supreme in its own field.

One of the special uses to which the electric furnace may be put, as told by Mr. Auguste J. Rossi elsewhere in these pages, is the making of special pig-irons, notably a "titanic" pig. In the Sault Ste. Marie experiments also, a ferro-nickel pig containing 4½ per cent. of nickel and virtually free from sulphur, was smelted from wasted and briquetted nickeliferous pyrrhotite containing about 1.6 per cent. of sulphur. The estimated value of the ferro-nickel pig is given as $40 to $44 per ton.

The Canadian experiments have undoubtedly given much valuable data, which will enable improvements to be made by Dr. Héroult with a view to greater economy. One of the ways in which the cost of production may be reduced is in the greater utilization of the calorific value of the fuel. This was the object sought in two short runs using air blast. The effect of this blast on the working of the electric furnace is an interesting one.

The electric furnace charge differs from that of the blast furnace in that with the latter the ore and the fuel are mixed, while in the former, the ore is first put in, and the fuel is then fed in through a hollow electrode. The fuel lies at the bottom of the ore, and the carbon monoxide generated rises through the ore, reducing it and being converted into dioxide. However, the power of the monoxide to reduce the ore lessens as it rises and all of it is not converted to dioxide.

The air blast was introduced to make the combustion of the monoxide complete. The higher the point of application of the blast, the more ore will be reduced and the monoxide will remain to be converted. The lower the point of application, the more monoxide will be converted, but the less ore will be reduced. In the blast furnace, carbon is present throughout; the charge and the carbon dioxide rising through it, is converted to monoxide and passes off as waste gas, as far as the blast furnace itself is concerned. It is in this utilization of the calorific value of the fuel that the electric furnace far exceeds the blast furnace.

Referring again to special uses of the electric furnace, it is interesting to note the suggestion of Mr. Rossi that it be used as an auxiliary to the blast furnace for the smelting of a special "titanic" pig. The idea of using the electric furnace for refining steel made in the open-hearth process or for making steel from pig-iron smelted in the blast furnace is not a new one, but the author's plan is essentially different.

Using that part of the blast-furnace gas which is not needed for other work, it is suggested that current be generated by gas-engine-driven dynamos for smelting titaniferous ores in the electric furnace. The idea is certainly a novel one, and coming, as it does, from an engineer of unquestioned ability, deserves consideration.

Arguments That Work Both Ways

NEARLY all electric companies charge for current by one or the other so-called differential systems with prices varying from 20 cents per kilowatt-hour or unit down to 1 cent per unit. Although these differential systems are planned so as to make the price of the unit proportional in all cases to the cost of producing it, many customers object to the complication and say they prefer a single uniform rate irrespective of cost.

A railway company recently applied to an electric light company for current to light twenty or thirty railway stations in the territory of the electric company and asked to be given a single uniform rate, the same for each station, irrespective of whether the stations used the light in an expensive or inexpensive manner. The railway company said that it did not want to be bothered paying different rates for different stations or to have differential rates on the same bill. The electric company replied that it would be very glad to make this arrangement, provided the railway would likewise agree to make

a uniform rate per ton-mile for the business the railway should do for the electric company, whether on fifth-class or first-class rate or on passenger traffic.

In another case, a customer of an electric light company complained of the bill because the meter was found 10 per cent. fast. The company agreed to rebate the bill, but the customer then asked that they go back for two years and rebate every bill that had been rendered since the meter was installed. Before the settlement, the company found, in another location, another meter of the same customer that was 20 per cent. slow. The customer, however, was not willing to go back two years in adjusting bills on this meter.

Still another case was that of a municipal plant near Boston, which showed very low figures for fixed charges because it ran without any reserve plant. Finally the engine broke down and half the town was in darkness for one night. The next night, in order to be impartial, that half the town was given light and the other half was left in darkness. An employee of the Edison Company suggested to one of the prominent newspapers that it should publish a story about this. The paper refused, giving as a reason that the breakdown was for only a few days.

The Edison Company maintains sufficient reserve so that in case of an ordinary or even extraordinary breakdown, the city shall not be in darkness. Supposing, however, that the Boston Edison Company should have a breakdown sufficient to put half of Boston in darkness. Would not this paper have considered it of general interest?

To cite a final instance, a street railway company recently applied to an electric light company for current between midnight and 5 A. M., when the railroad company's plant was shut down. The latter company asked for especially low rates, for the reason that this supply did not come at the peak of the electric light company's load and therefore did not cost that company anything except for coal.

The electric light company replied that it would make especially low rates for this service, provided the street railway company would likewise recognize the corresponding situation and whenever any of its cars were not full, would carry employees of the electric light company at a price corresponding to the excess coal needed to carry the extra weight, since of course whenever a car was not fully loaded, putting on an extra passenger added nothing to the expense of the street railway company except the extra coal necessary.

Electrical Opportunities in Cuba

NO foreign field offers better opportunities for the sale of electrical machinery and devices than Cuba. In a letter to Secretary Metcalf, of the Department of Commerce and Labour, Special Agent C. M. Pepper predicts increased markets for United States products, including electrical apparatus, railway equipment and rolling stock.

The foreign commerce of Cuba approximates $200,000,000 annually, and this year the value of products imported from the United States is placed at $50,000,000. The buying ability of the island has been somewhat lessened through the decreased production of sugar and the shortage in the tobacco crop due to floods, yet this will be offset by the large amounts of capital now being transferred from the United States and Europe for investment in new railroads, trolley lines, municipal improvements, and miscellaneous enterprises. Labour is scarce and wages are high, so that the transferred capital assures the continuance of industrial activity.

In electric apparatus, railway equipment, and rolling stock, besides some forms of iron and steel manufacture, agricultural implements, sewing machines, typewriters, weighing scales and bicycles, Mr. Pepper says that the United States has substantially the whole trade. This statement, however, is entirely at variance with that made by C. L. Michod, general manager of the Interstate Electric Company, of Havana, in a recent interview given in "The Manufacturers' Record."

"The United States," he says, "are far behind Germany in imports of electrical equipment for illumination and power and water-works apparatus. If we are to secure our share of this business, as we should, American houses should send men to secure business who are practically as well as theoretically the equal of German representatives. This, of course, includes a thorough knowledge of the Spanish language, otherwise American houses are placed at a disadvantage of such a serious nature that they need not expect to be successful in competition to any extent."

That conditions of credit have prevented American manufacturers from getting a large share of Cuba's trade is well known. The German and Englishman are content to wait a long time for payment; but if it be the case also, that representatives of German electrical houses overshadow those of American companies, certainly the only remedy is to place in the field competent men familiar with the language and customs of the island. The organization of the German consular service is well known. Doubtless the same thoroughness characterizes the choice of representatives of commercial houses.

Of the enterprises which will create a demand for electrical apparatus, the more important perhaps are the extensions to the Havana Electric Railway and those to the Havana Central Railroad. Contracts for the additional equipment of these lines have already been let, but it is the development which these will engender with which we have to deal.

The Havana Electric Railway is at present operating 52 miles of line in Havana and its vicinity, and the Havana Central Railroad is operating 120 miles in the province of Havana. In both cases, large improvements are under way and the equipment will be doubled. The franchise of the latter company carries with it the exclusive right of building and operating electric light plants in towns along its lines. Two have already been built, one at Regla and the other at Guanabacoa, and still more are contemplated.

In the new territory opened up, and with electric current available, little difficulty should be encountered in securing customers for electrical apparatus. In a hot country, where the people are constitutionally languid, the electric motor will appeal to many as offering a means of escape from any effort which the heat makes uncomfortable. Electric fans and electrically operated refrigerating apparatus should aid in making life more endurable, and electric cooking apparatus and flat-irons will take away the terrors of cooking over a hot fire or of laundry work near one.

One of the cities to be connected by an electric line is Puerto Principe, and this, says Mr. Michod, is in a region devoted largely to farming. It is the headquarters for American investors and those identified with farming interests, and is becoming Americanized rapidly. Here, then, should be a field for the use of motors in farming operations. On account of the preponderance of Americans, no handicap of conservatism or lack of familiarity with electric devices are present to prevent the ready sale of electrical devices. Americans, furthermore, will undoubtedly prefer an American made article to one

made in a foreign manufactory. Another new suburban line runs to Guimes, and many important American interests are centered there. What applies to Puerto Principe, then, also holds good here, and American products would doubtless be given the preference by American purchasers.

This brief outline, then, will give some idea of the opportunities that exist in Cuba. That the country is still largely undeveloped in many ways is evident, and if the correct methods are used to get business, there is no reason why the American products sold should not far outnumber those of other countries.

Amending the Constitution of the American Institute of Electrical Engineers

THE result of the letter balloting for officers of the American Institute of Electrical Engineers and on the proposed amendments to the constitution was announced at the annual meeting of the Institute, Tuesday, May 15, a report of which will be found in another part of this issue.

As we editorially predicted would be the case in our May number, the proposed amendments to the constitution failed to receive the necessary majority of the entire membership in their favour, the vote being 1507 for and 161 against the amendments. As the majority of 1345 was below that necessary to adopt the amendments, they were declared lost.

In the discussion that followed the announcement of this vote, the chairman of the law committee, which had in hand the formulation of the proposed amendments, said that the result of the balloting had shown him very clearly that the only hope for any change in the constitution must first be by amending the amending clause of the constitution so that considerably less than a majority of the total membership of the Institute might be empowered to effect amendments to the constitution. This, by the way, conforms to a view we expressed in the editorial previously referred to.

The main objection offered to the proposition to thus amend the amending clause of the constitution, is that it would perhaps place too much power in the hands of the New York and Brooklyn members. For our part, we fail to see the force of this objection. We have watched the progress of the Institute closely for many years, and we have yet to learn of a single instance in which the New York members have ever attempted to arrogate to themselves any rights or privileges that, within reason, were not open to the members at large.

It is true that the regular monthly meetings of the Institute are held in New York City, and naturally so, that city being the headquarters of the Institute. The annual conventions of the Institute, however, at which are usually read and discussed the most important papers of the year, are rarely held in that city, and the branch meetings of the Institute afford the members in the various parts of the country opportunities almost equal to those enjoyed by the New York members for the discussion of the papers presented to the Institute.

In the selection of the presiding officer of the Institute since its organization, it can hardly be asserted that the New York members have been unduly selfish. If we eliminate from consideration the first four presidents of the Institute, say from 1884 to 1890, during which time the Institute was practically a body local to New York as regards membership, it will be found that eight out of thirteen of the presidents since elected were not residents of New York City. In short, it has become a proverb, but one which it is difficult for many provincials to appreciate, that residence in a cosmopolitan city or neighbourhood engenders broad views that render the cosmopolites exceedingly open to any suggestions looking to a liberal distribution of the benefits which they enjoy to all parts of the country, and the cosmopolitan members of the Institute form no exception to the working of this proverb.

A Novel Telephone Exchange

ONE of the most unique places which the earthquake at San Francisco destroyed was the Chinese telephone exchange, the only one of the sort in the country.

Every guide to Chinatown took his charges to the exchange, permitting them to stand just beside a rail separating the operators from the rest of the room, while he explained that because the Chinese numbers were so inordinately long, the plugs were not numbered for the respective subscribers, but, instead, one called for a party by name. The operator would repeat this name back to the caller, to make sure he heard aright, and meantime made the connection. Nor did the plug bear the respective names; on the contrary, they were blank, and this made it necessary that each operator recall just which jack belonged to each subscriber.

The Chinese telephone exchange was in operation about nine years, and in that time the number of subscribers had reached about 900. At first many of the Celestials were superstitious about using the instrument, believing that the electricity would make them ill, and there is still a small number of that firm belief.

Even though the operator had to remember each subscriber's name and jack, really quick service was had. When the operator's memory failed him, however, he referred to a directory printed in Chinese. How much space is saved by substituting name for number may be seen when it is stated that in Chinese, 808 would be bat-bak-soh-gow-bat, while the subscriber's name might be simply Sang Fat.

The experience of new subscribers with the telephone was often very amusing, not a few of them believing that they must blow into the transmitter to call the central office. All the Joss houses of Chinatown had the telephone located in the secretary's office, and yet the Chinese would never mention the dead in talking over the telephone.

Sixteen operators were employed in all, alternating day and night-shifts, and all of them were Chinamen. In addition, two little girls were employed, one to run errands, and the other to act as a guide and interpreter to resorts to which Americans were denied access, and to which telephone operatives were probably the only whites that ever gained access. The Chinese are prompt payers of telephone bills, and if business seems to threaten that payment will be impossible the next month, they have the telephone taken out. Good use was made of the long-distance telephone to both Los Angeles and Portland. On the first two days of the Chinese New Year nearly all Celestials refrain from using the telephone.

A perfect chemical mixture of carbonic oxide and air will require from .04 second to .07 second to become carbonic acid upon ignition per cubic foot of gas. This is too short a time for the boiler furnace, through which the gases pass at a rate of from 20 feet to 50 feet per second. It is very important to reduce the amount of air close to that theoretically required for the combustion of the fuel, for the excess of air frequently takes away 15 per cent. of the total heat value.

NIGHT VIEW OF THE ENTRANCE TO YOUNG'S PIER, ATLANTIC CITY. IT IS ON THIS PIER THAT THE MEMBERS OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION ARE TO MEET IN CONVENTION

The Atlantic City Convention of the National Electric Light Association

THE preparations now going on for the entertainment of the members and guests of the National Electric Light Association at the Atlantic City convention indicate that a very enjoyable time will be had at the well-known seaside resort. Young's Pier ought certainly to prove a desirable meeting place for the business sessions, situated, as it is, to receive the full benefit of the cooling sea breezes.

Atlantic City's hotel facilities for taking care of visitors are well known, and, according to a circular recently sent out by Arthur Williams, chairman of the convention committee, the rates offered are certainly attractive and varied enough to suit many different tastes. A map of the ocean front is given in the circular, so that the location of each hotel and Young's Pier may be found.

The business sessions promise to be of more than usual interest. The great number of items for the Question Box, of which Paul Lüpke is editor, promises to bring out some very valuable information for central station men. The question of business-getting, also, has received, during the past year, greater attention than ever; hence the special exhibit of the various means of ad-

THE NEW MARLBOROUGH-BLENHEIM HOTEL AT ATLANTIC CITY. A RECEPTION WILL BE GIVEN HERE DURING THE CONVENTION

vertising employed by central stations will be of special interest.

This exhibit will be under the personal direction of T. C. Martin, who inaugurated it at the Denver convention last year. A hall adjoining the place of meeting has been set aside for the exhibit.

The secretary's office for the registration of members will be at the right of the entrance to the Pier, and here, after becoming settled at the hotels, members will go to register and receive their badges. The association badge entitles the wearer to free admission to the Pier at all times, and also to all the attractions on the Pier to which the general public must pay 10 cents admission. During the convention an excellent band will furnish morning, afternoon, and evening concerts, and a vaudeville theatre and a skating rink will add to the entertainment of the visitors. At the front of the Pier, also, arrangements have been made for a thousand rocking chairs.

The more elaborate features for entertainment include a reception at the Marlborough-Blenheim, a trip to Philadelphia by special train, including luncheon at the Bellevue-Stratford, and possibly a convention banquet later in the week.

The associates' exhibits will be in the large room at the end of the Pier, adjoining the board walk. Between 10,000 and 12,000 square feet are here available. A list of the exhibitors, which was complete up to the time of going to press, is as follows:—

The Addressograph Company, Chicago.

The Allis-Chalmers Company, Milwaukee, Wis.

The American Circular Loom Company, Chelsea, Mass.

The American Electrical Heater Company, Detroit, Mich.

The American Instrument Company, Philadelphia.

The American Vibrator Company, St. Louis.

The Automatic Refrigerating Company, Hartford, Conn.

The Beck Flaming Lamp Company, New York.

"The Central Station," New York.

The Curtis Advertising Company, Detroit, Mich.

The Dearborn Drug & Chemical Works, New York.

"The Electrical World," New York.

"The Electrical Review," New York.

The Electric Storage Battery Company, Philadelphia.

The Excello Arc Lamp Company, New York.

The Federal Electric Company, Chicago.

The Fort Wayne Electric Works, Fort Wayne, Ind.

The General Electric Company, Schenectady, N. Y.

The General Storage Battery Company, New York.

John L. Gleason, Jamaica Plain, Mass.

The Illuminating Engineering Publishing Company, New York.

The H. W. Johns-Manville Company, New York.

The Metropolitan Engineering Company, Brooklyn.

The Mayer & Englund Company, Philadelphia.

A. F. Moore, Philadelphia.

Niagara Tachometer & Instrument Company, Niagara Falls.

Oneida Community, Oneida, N. Y.

The Phelps Company, Detroit, Mich.

The Philadelphia Electrical & Manufacturing Company, Philadelphia.

The Sangamo Electric Company, Springfield, Ill.

The Simplex Electric Heating Company, Boston.

The Southern Exchange Company, New York.

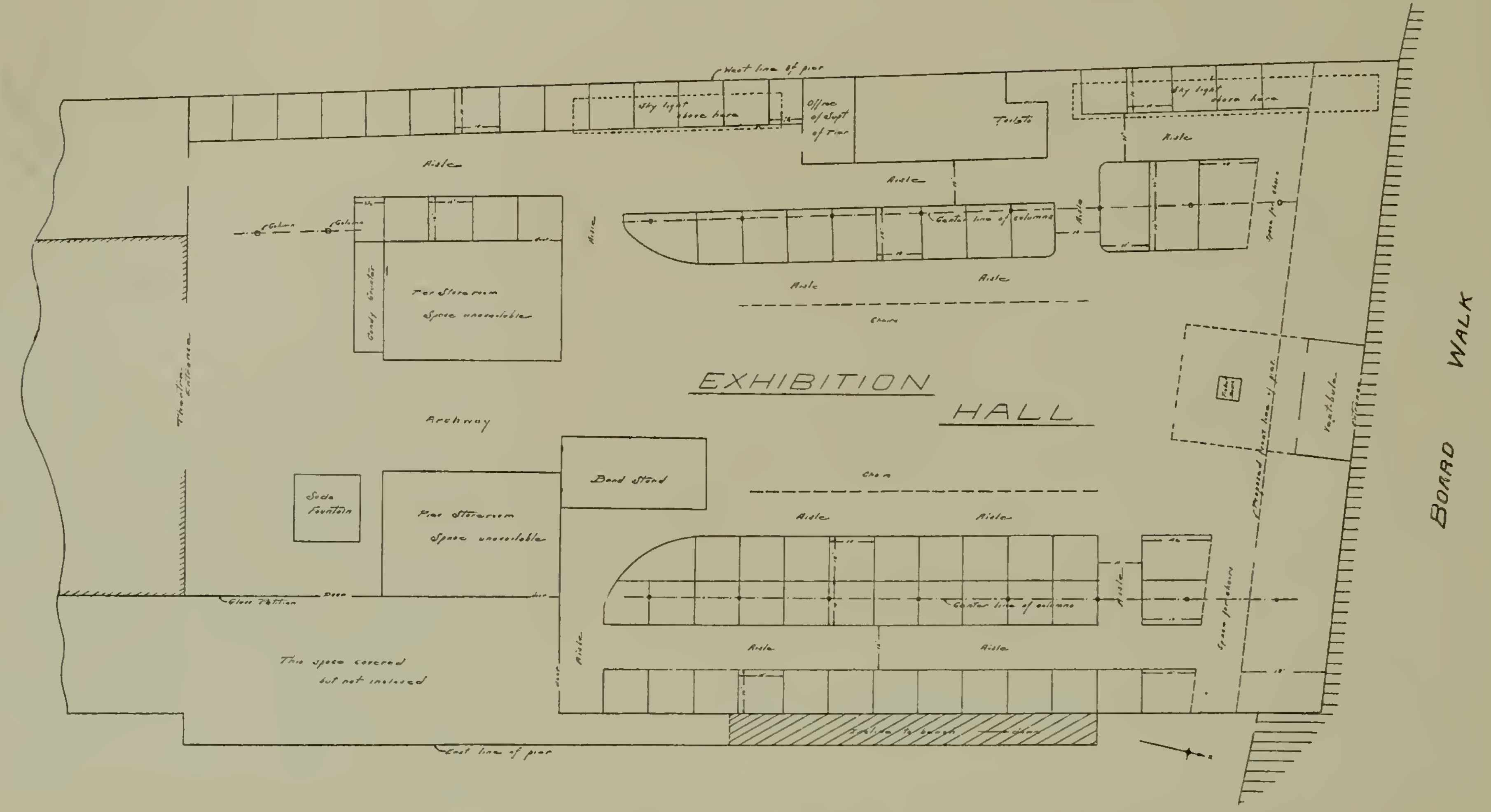
The Stanley-G. I. Electric Manufacturing Company, Pittsfield, Mass.

The Standard Vitrified Conduit Company, New York.

The Standard Paint Company, New York.

The Wagner Electric Manufacturing Company, St. Louis.

The Westinghouse Companies' Publishing Department, Pittsburg.



PLAN OF EXHIBITION HALL ON YOUNG'S PIER, ATLANTIC CITY

Annual Convention of the American Institute of Electrical Engineers

THE preparations for the Milwaukee convention of the American Institute of Electrical Engineers are practically complete as we go to press, and the indications are that the meeting will be a very enjoyable one.

One of the features provided for the entertainment of the visitors will be a trip through the works of the Allis-Chalmers Company, a luncheon being provided at the West Allis works, on the outskirts of the city. An opportunity will thus be afforded the members of inspecting the new extensions to the West Allis plant, which will, when completed, add in all 861,000 square feet to the plant's present floor area. These extensions involve an expenditure of over $3,000,000.

An interesting feature of the plant's equipment is an electric telpherage system, running through the various sections, and used for handling patterns. The yards between the various sections are also equipped with cranes, so that the space available may be used for storage.

Judging by the list of papers to be read during the sessions of the convention, they and the discussions of them ought to prove of interest to a great number. The headquarters of the Institute during the convention will be at the Hotel Pfister. The members of the local committee are:—John I. Beggs, chairman; W. E. Dodds, W. F. Johnson, H. H. Cutler, and Chas. W. Burkett.

In addition to those papers, a list of which was given in these pages last month, the following are to be read:—

"Comparison of Two and Three-Phase Motors," by Bradley McCormick.

"The Self-Synchronizing of Alternators," by Morgan Brooks.

"Electrical Connections for Power Houses," by David B. Rushmore.

"Some Fundamental Characteristics of Mercury Vapor Apparatus," by Percy H. Thomas.

"Some Notes on the Lighting of Churches," by Edwin R. Weeks.

PAUL M. LINCOLN

Recently Elected Manager of the American Institute of Electrical Engineers.

DR. SAMUEL SHELDON

The New President of the American Institute of Electrical Engineers

H. H. HUMPHREY

Recently Elected Vice-President of the American Institute of Electrical Engineers

"Standardization Rules." The proposed revision of the existing Standardization Rules will be reported for discussion by the Committee on Standardization.

ANNUAL MEETING

The usual annual meeting before the annual convention was held in the Edison Auditorium, on West Twenty-seventh street, New York. As a result of the votes polled the following officers were declared elected:—

President, Samuel Sheldon, of Brooklyn.

Vice-presidents, A. H. Armstrong, of Schenectady; H. H. Humphrey, of St. Louis; F. G. Baum, of Oakland, Cal.

Managers, Paul Spencer, of Philadelphia; P. M. Lincoln, of Pittsburg; J. J. Carty, of New York; A. M. Schoen, of Atlanta.

Treasurer, Geo. A. Hamilton, of New York.

Secretary, R. W. Pope, of New York.

Three vice-presidents and eight managers hold over.

For the constitutional amendments, the vote was 1507 in favour and 161 against. As the vote was below the majority required to pass the amendments, they were declared lost.

The report of the board of directors for the fiscal year ending April 30, 1906, showed that the total membership of the Institute is now 3870, an increase during the year of 410.

JOHN J. CARTY

Recently Elected Manager of the American Institute of Electrical Engineers

The number of students enrolled is 618.

As told in the May number of THE ELECTRICAL AGE, an invitation was received from the Italian Electrotechnical Association, inviting the Institute to visit the Milan Exposition and other places in Italy during June; but it was found that the number who signified their desire to attend was too small to warrant the Institute being officially represented, and consequently the Italian trip has been postponed to a future season.

Regarding the visit to London, it was announced that a number of members were to accept the invitation of the British Institution of Electrical Engineers.

In March, 1906, the resolutions adopted by the standardization committee in favour of the metric system were submitted to the membership for a letter ballot, and the Congressional committee in charge of the pending bill relating to the metric system was notified. The result of this ballot was 1569 in favour and 178 against the resolutions.

The work on the United Engineering Building, it was reported, was progressing very rapidly. The walls were up to the thirteenth floor, the steel work was finished, the plumbing and electric risers were up to the fifth floor, the heating risers to the sixth floor, the metal lathing and the partitions were started, and the boilers were set.

The report of the committee on finance showed that the ordinary receipts during the fiscal year were $49,423.43, the ordinary disbursements, $40,767.22, and the net cash gain was $8,656.21. The bank balance available for current expenditures on April 30 was $14,979.09. Adding to this sum the market value of the United States bonds owned by the Institute, $8320, makes a total of $23,299.09 in cash or its equivalent immediately available.

Under the founders' agreement with the United Engineering Society, the Institute is pledged for its share of the cost of the land upon which the United Engineering Building is being erected. This share of indebtedness is $180,000, upon which 4 per cent. interest is being paid from the building fund. The principal is due in twenty annual payments, and it is to this purpose that the land, building and endowment fund is to be devoted, and assessments of the United Engineering Society have been paid out of this fund. The advance payment of about one-quarter of the principal is now under consideration.

The report of the library committee showed that there are 10,108 volumes and 515 pamphlets in the library. The valuation, including permanent library fixtures, was as follows:—Books, $22,069.31; book stacks, $1,470.25; furniture, catalogue cases, etc., $135.20.

A vote of thanks was tendered the New York Edison Company for the use of the Edison Auditorium, and also to the New York Telephone Company for the use of its board room for a meeting place of the board of directors of the Institute.

Chas. F. Scott, in speaking of the failure of the members to adopt the amendments to the constitution, said that he thought that not enough time and opportunity had been given them for weighing the matters presented to them or for considering the reasons for their adoption. He therefore moved that the board of directors be requested to afford means for the members at large to take part in a consideration of the proposed new constitution.

The motion was seconded by C. C. Mailloux. Dr. Perrine offered an amendment that the council consider the advisability of issuing an independent circular to the chairmen of the local sections, asking them to make a personal canvass in order to bring out the fullest possible vote. The motion as amended was carried.

The Chattanooga Meeting of the American Society of Mechanical Engineers

THE fifty-third meeting of the American Society of Mechanical Engineers was held in the auditorium of the Masonic Temple, in Chattanooga, Tenn.

At the opening session on Tuesday, May 1, Mayor Frierson addressed the members. On Wednesday, the committee on standard proportions for machine screws made its report, as did also the committee appointed to co-operate with the Pennsylvania Railroad Company in conducting tests of locomotives at the Louisiana Purchase Exposition.

During the remainder of the business sessions, the following papers of electrical interest were read:—

"A Low Resistance Thermo-Electric Pyrometer and Compensator," by Wm. H. Bristol.

"The Improvement of the Tennessee River and Power Installation of the Chattanooga & Tennessee River Power Company at Hale's Bar, Tenn.," by Thos. E. Murray.

"The Regulation of High-Pressure Water-Wheels for Power Transmission Plants," by Geo. J. Henry, Jr.

"Speed Regulation of Water-Power-Plants," by John Sturgess.

"Efficiency Tests of Turbine Water-Wheels," by Wm. O. Webber.

"Turbine Design as Modified for Close Regulation," by George A. Buvinger.

"Some Stepping Stones in the Development of a Modern Water-Wheel Governor," by Mark A. Replogle.

An Electric Elevator With a 495-Foot Lift

THE station on the Burgenstock Mountain Railway, at the end of the line near Lake Lucerne, in Switzerland, is about 510 feet below the summit, says "The Electrical Engineer," of London. An electric lift has recently been erected, and set to work with a vertical travel of 495 feet. The lower part of the metallic guides are anchored in a shaft excavated through the rock

The upper braced lattice work, representing 385 feet of the total length, is attached to the almost perpendicular mountain by supports at different points. A bridge 37½ feet long connects the top of the lift-race with the mountain, across which is the exit for the passengers.

The exit at the bottom of the shaft is by a horizontal tunnel cut through the rock to the station platform. The time taken for the ascent is three minutes, the motive power being supplied by a 25-H. P. motor working at a speed of 900 revolutions per minute on a 1200-volt circuit. When, however, a train is approaching a station, the voltage drops as low as 900, with a consequent reduction in the speed of the lift motor. Automatic stopping and safety devices are employed, to comply with the requirements of the official regulations.

In a paper read before the British Physical Society, J. A. Harker gave an account of experiments made some years ago at Kew Observatory on the earth currents produced by electric traction schemes, and on the disturbances they cause on the self-recording magnetic instruments kept continuously running to register the variations in the declination and the horizontal and vertical forces. Two large earth plates were buried about four feet deep and two hundred yards apart, and connected through a photographic recording voltmeter of high resistance. On the traces given, the effect of the trains on the Central London Railway was strikingly shown. The nearest point to Kew is about six miles distant.

Electric Rock Drills

By W. H. RADCLIFFE

FIG. 1.—OPERATING POSITION OF THE ROTARY ELECTRIC ROCK DRILL MADE BY THE JEFFREY MANUFACTURING COMPANY, COLUMBUS, OHIO, IN DRILLING VERTICAL FACES

THE economic advantage of electric motive power for rock drilling has been well established by the electrical installations of this nature in succesful operation, and by the large increase in their number from year to year.

Electricity is particularly well adapted for drilling on account of the ease and simplicity with which it can be transmitted over long distances and underground. In mining work particularly, it is essential that the power used be generated as economically as possible, and experience has shown that this means a central location for the power supply. However, unless the power thus generated can be economically transmitted and distributed, but little is gained.

The advantages which electricity possesses over compressed air, steam, and hydraulic pressure in this respect have therefore counted for much in its favour. With electricity there is no freezing nor loss by condensation, radiation, or from leaky joints of pipes, which in the other systems are liable to cause trouble.

The flexibility of the power transmission line is another point not to be overlooked, and in this respect the electric system is unsurpassed. It is also cheaper to construct, and, if necessary, incandescent lamps and electric blowers may be connected to the same circuit that is furnishing power to the drill and used for lighting and ventilating the mine.

The Western States have been considerably in advance of the Eastern States in the application of electricity to rock drilling. Many of the mines in Colorado and in the neighbouring States have installed electric drills, and in nearly all excavation work, such as tunneling and grading for railroads, electrically driven tools are now used throughout that section of the country.

In the Eastern States, steam and compressed air have been mostly used for this work, but the number of electric drills here installed within the past year shows that their good points are becoming generally known and appreciated, and that the next few years will witness considerable progress in the application of electricity in this direction.

Electrical apparatus, as a rule, cost less and are more compact than machines operated by a different form of energy; they are also highly efficient, so that their operating expense is low. For example, tests in quarry excavating in New York City on the Durkee electric drill, made by

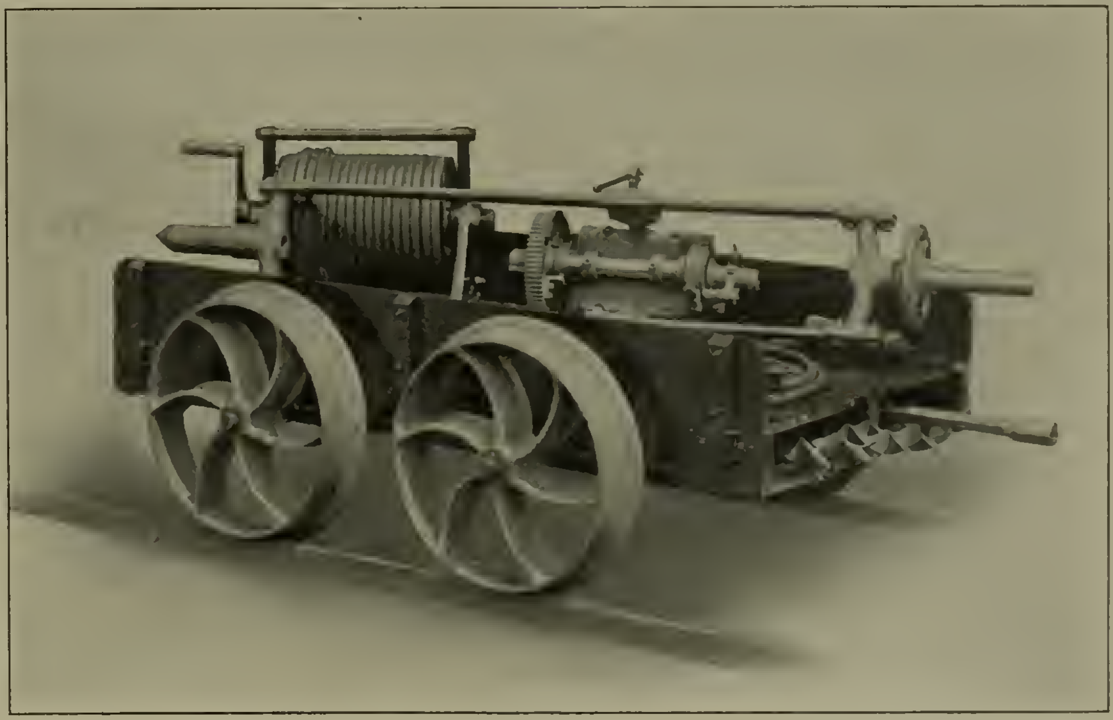


FIG. 2.—TRUCK FOR MOVING JEFFREY ELECTRIC DRILLS FROM PLACE TO PLACE

FIG. 3.—JEFFREY ELECTRIC DRILL FOR USE IN ORDINARY GRADES OF COAL, SLATE, AND CLAY

FIG. 4.—JEFFREY ELECTRIC DRILL FOR USE IN SOFT ROCKS AND IN HARD CLAYS AND SHALES

the Mine & Smelter Supply Company, of Denver, Col., showed an average drilling of over 60 feet per day at an average cost of but 1.5 cents per foot. These tests were made by the New York Edison Company at the 121st-street station, and the results obtained are given herewith:—

Date	No. of Holes Drilled	Depth in In.	No. of Working Hours per Day	Time Lost Blasting and Mucking	No. Ft. Drilled per Day	Kw. Hr. Consumed	Cost per Day
1935				Hr. Min.			
Apr. 21..	12	58	6½	30	58	8.7	$ .87
22..	15	58	8	1	73	10.9	1.09
23..	13	58	8	1 20	63	9.4	.94
25...	12	58	8	1 15	58	8.7	.87
26...	13	58	8	1 15	63	9.4	.94
27...	2	58	1	5	10	1.5	.15
28..	12	58	8	1 10	58	8.7	.87
29...	13	58	8	1 50	63	9.4	.94
May 1..	3	58	2½	40	15	3.2	.32
2..	10	58	7	35	48	8.2	.72
3...	8	58	6	50	39	5.8	.58
4...	2	58	1		9	1.3	.13
5..	9	58	6	40	44	6.6	.66
6...	11	58	8	45	53	7.9	.79
8...	12	58	8	25	58	8.7	.87
9...	13	56	8	30	63	9.4	.94
10...	11	58	8	20	53	7.9	.79
11...	5 6	58 74	8	35	61	9.0	.90
12...	5 6	74 36	8	1 5	49	7.4	.74
13...	16	36	8	45	48	6.3	.63

On April 21 and 27 and May 1, 2, 4 and 5, a heavy rain prevented a full day's work.

A second test was made at the northeast corner of Twelfth street and Fourth avenue with the following results:—

Date	No. of Holes Drilled	Depth in In.	No. of Working Hours per Day	No. Ft. Drilled per Day	Kw-Hr. Consumed	Kw-Hr. per Ft.	Cost per Ft. Cents	Cost per Day
July 5..	17	48	8	68	8.09	.131	1.31	$.89
6..	17	48	8	68	8.35	.123	1.23	.835
7..	18	48	8	72	8.06	.120	1.20	.86
8..	3	48	1.5	12	.05	.04	.40	.05
10..	11	48	6	44	4.05	.92	.92	.405
11..	20	36	8	60	6.45	.107	1.07	.645

On July 8 and 10, the work was stopped on account of rain. At both 121st street and Twelfth street the rock is of mica schist, and muds easily.

The design of electric rock drills has been given considerable attention by many prominent engineers, and much money has been spent in an effort to make them satisfactory in every detail. A number of different types of electric rock drills are here shown,—some are of the rotary type and others are of the percussion type,—but the examples given do not represent all of the various designs on the market.

Figs. 3 and 4 show two types of electric rotary drills designed by the Jeffrey Manufacturing Company, of Columbus, Ohio, for drilling in coal, clay, shale, slate, and soft rocks. The drill shown in Fig. 3 is suitable for the ordinary grades of coal, slate, and clay, and the double reduction

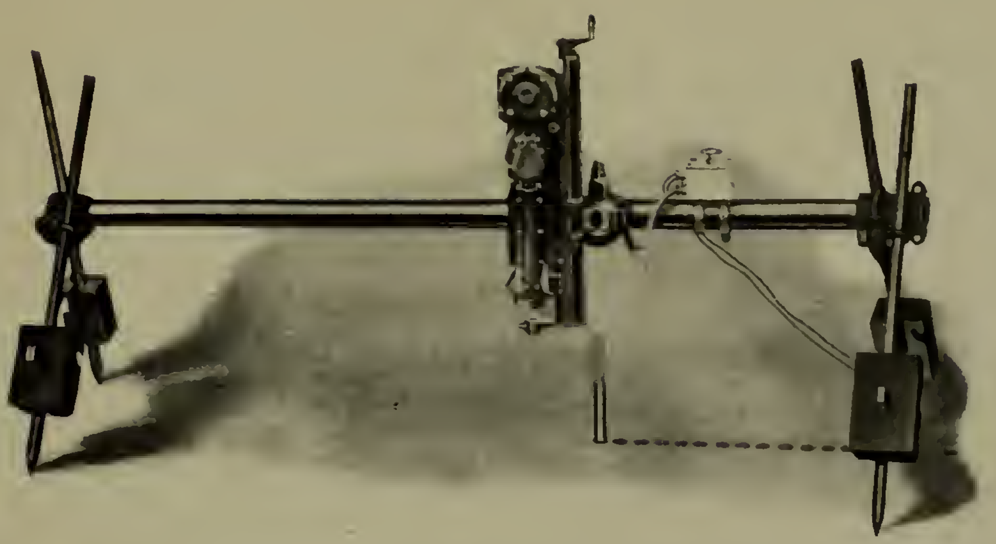


FIG. 5.—THE BOX ELECTRIC DRILL MADE BY THE H. D. CRIPPEN MANUFACTURING COMPANY, NEW YORK, IS MOUNTED AS HERE SHOWN FOR QUARRY WORK

drill shown in Fig. 4 is for soft rocks and the harder clays and shales.

In both these drills a steel auger is fixed at the end of a feed screw and driven by an electric motor. The motor and mechanism are mounted in an upright frame and can easily be raised and lowered for drilling holes at different heights. The frame itself is made suitable for the different heights of veins, and is also adjustable for variations in the height of a vein. The motors are wound for practically all direct-current voltages, and are rated at 1½ and 2 H. P.

A suitable cable reel, furnished with a long and a short cable, is supplied with each drill. The long cable is used between the main power line and the reel, while the short cable is used between the reel and the drill. Reels are ordinarily equipped with long cables measuring 230 feet, and short cables measuring 20 feet. A truck, as shown in Fig. 2, is also provided for moving the drills from place to place.

The augers are usually 3 feet and 6 feet in length, although a few 25 feet in length have been made, and will drill holes from 1¼ to 3 inches in diameter. Each auger is provided at the rear end with a square tapered shank which fits into a socket in the front end of the feed screw. The latter is fed forward by means of a split nut held in a casing, which is prevented from rotating by a friction band. The nut is held stationary under ordinary conditions of drilling, thus giving the screw its full speed of advance. However, should the drilling become too hard, the nut will rotate with the screw and relieve the pressure on the auger, thus preventing damage. By alternate tightening and loosening of the friction band, it is possible to regulate the speed of advance of the feed screw easily and quickly to meet all conditions.

In operation, the drill and frame are rigidly set up in a nearly vertical position, so that with a short auger and with the screw back as far as possible, the point of the auger just clears the face of the material to be drilled. The cable is then "plugged in," and the drilling begins. After the screw has advanced as far as the drill socket will permit, the split nut is opened, and the feed screw and auger withdrawn. The next longer auger is then inserted and the drilling continued. This operation is repeated until the necessary depth of hole is obtained.

In drilling vertical faces, the drill is placed as shown in Fig. 1. In surface work it is sometimes necessary to drill holes vertically down-

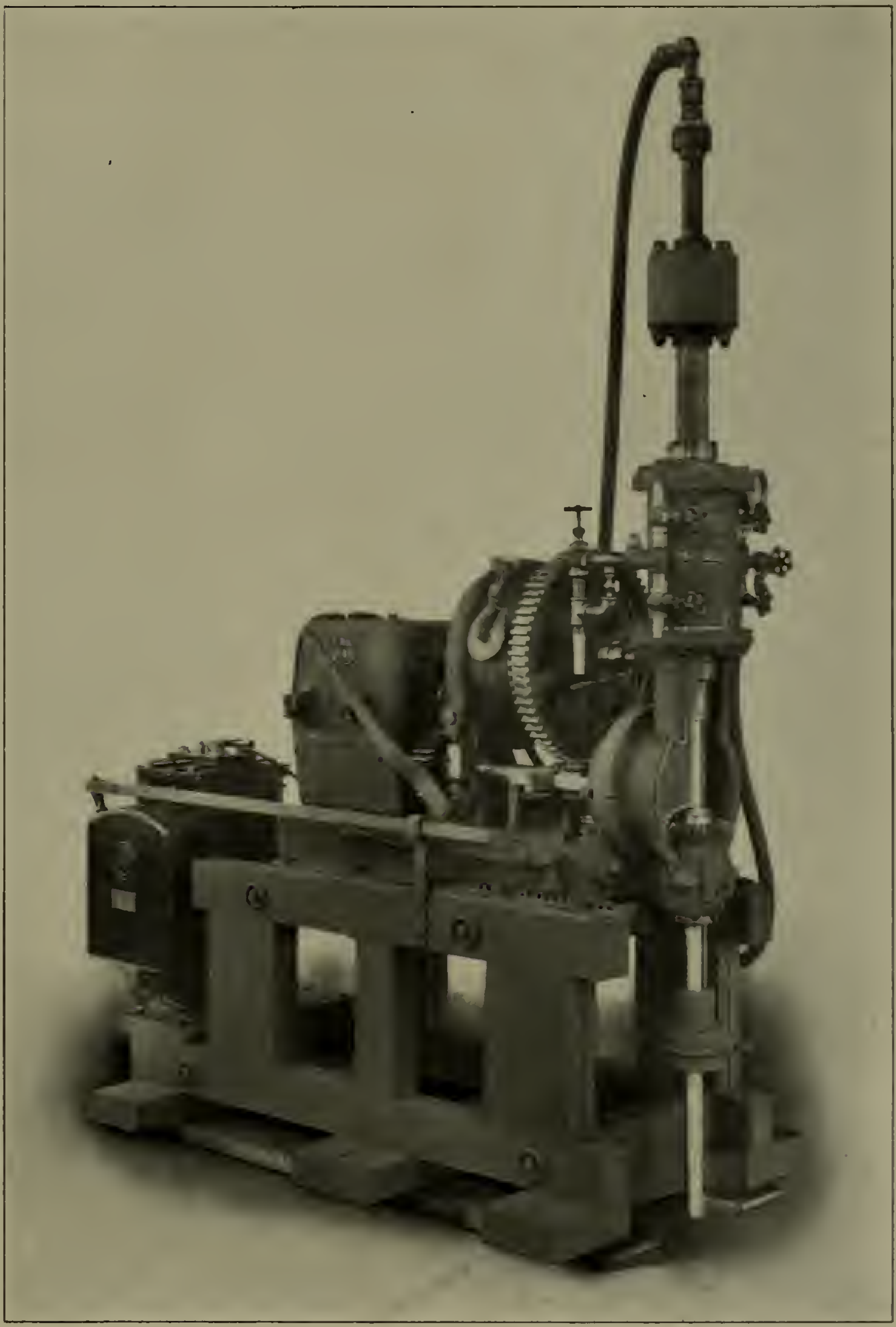


FIG. 6.—AN ELECTRICALLY DRIVEN DIAMOND DRILL WITH HYDRAULIC PRESSURE REGULATION. MADE BY THE SULLIVAN MACHINERY COMPANY, CHICAGO, ILL. BY APPLYING HYDRAULIC PRESSURE TO EITHER SIDE OF A PISTON THE DRILL IS RAISED OR LOWERED

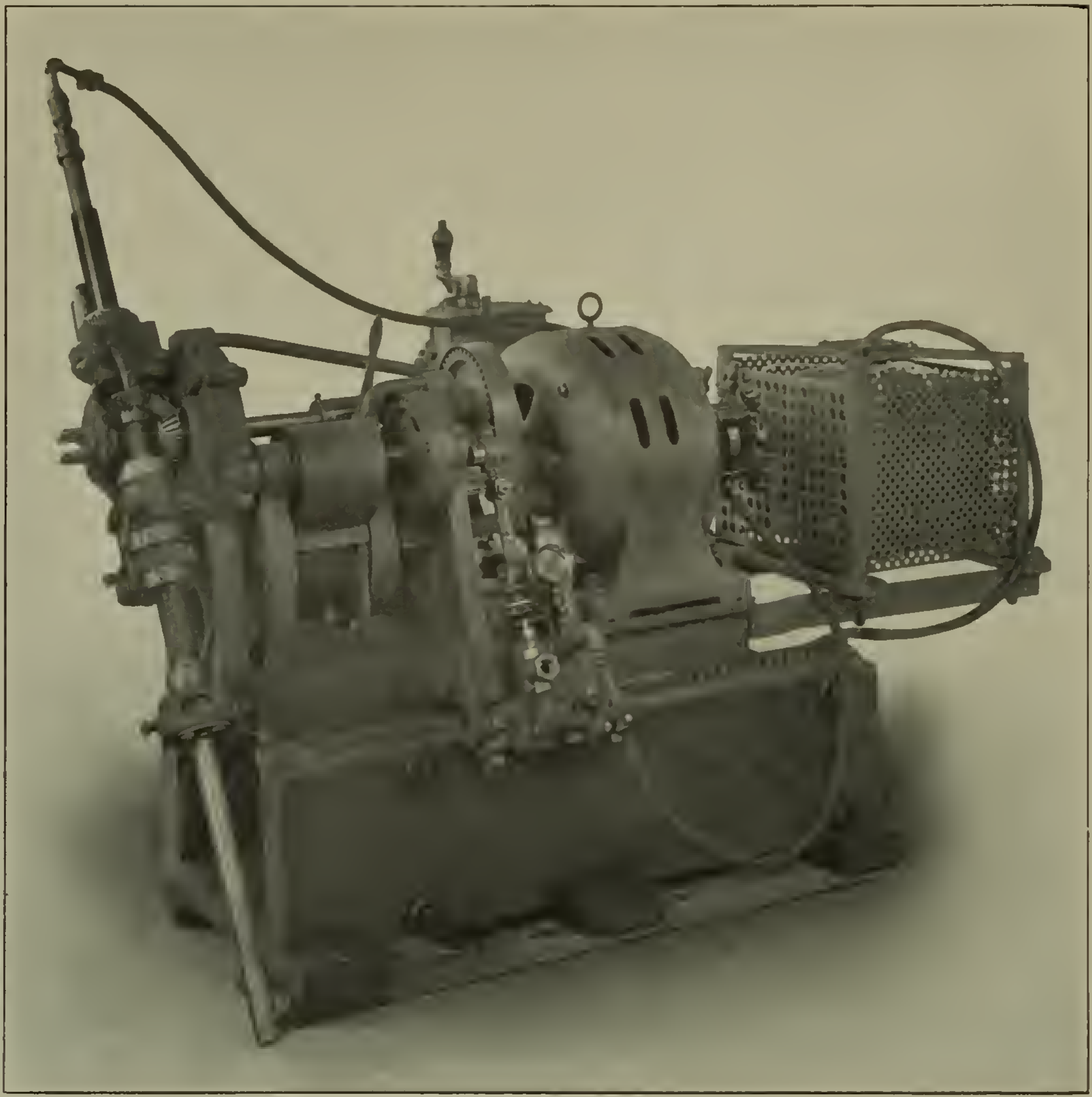


FIG. 7.—SULLIVAN ELECTRIC DIAMOND DRILL HAVING THE MOTOR AND THE PUMP USED IN SUPPLYING THE HYDRAULIC PRESSURE FOR FORCING THE CUTTINGS AWAY, MOUNTED ON THE SAME FRAME

ward. Under such conditions, the frame of the drill is mounted horizontally in a separate ballasted frame which can be moved from place to place over the surface.

Fig. 6 shows an electrically driven diamond drill made by the Sullivan Machinery Company, of Chicago, for prospecting. It is equipped with a hydraulic cylinder for applying the pressure for advancing the drill. By admitting water, under pressure, to one side of the hydraulic piston, and releasing an equal amount from the other side, the piston, and therefore the drill, can be moved either up or down.

The amount of water admitted to or released from the hydraulic cylinder is varied by adjusting the inlet and outlet valves, and the feed or advance movement of the drill depends directly upon this amount. Any change in the formation of the stratum penetrated is indicated at once by the gauges on the hydraulic cylinder, and the operator noting this can immediately change the feed to suit the new conditions.

In the Sullivan drill shown in Fig. 7, the electric motor for driving the drill, and the pump for forcing water through the rods to the bottom of the hole, to keep the hole clear from chippings and to enable the diamonds to cut more rapidly, are mounted on the same frame. The drill is fed in by means of a screw which has a pitch designed to give a suitable rate of advance according to the nature of the rock.

Among the percussion types of electric rock drills is the well-known Box drill made by the H. D. Crippen Manufacturing Company, of New York. This drill is shown in Figs. 5, 10, and 11. Fig. 10 shows the construction of the drill. Fig. 11 shows it mounted on a cross-bar for tunneling or stoping work, and Fig. 5

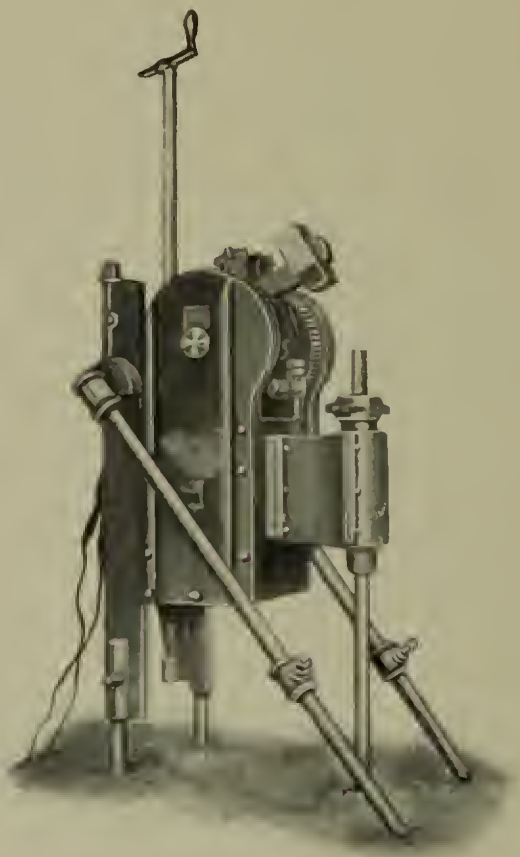


FIG. 8.—A PERCUSSION ROCK DRILL, OPERATED BY ELECTRIC HAMMER BLOWS

FIG. 9.—THE DEITZ ROCK DRILL MADE BY THE F. M. DAVIS IRON WORKS COMPANY, DENVER, COL., IS ELECTRICALLY DRIVEN THROUGH A FLEXIBLE SHAFT

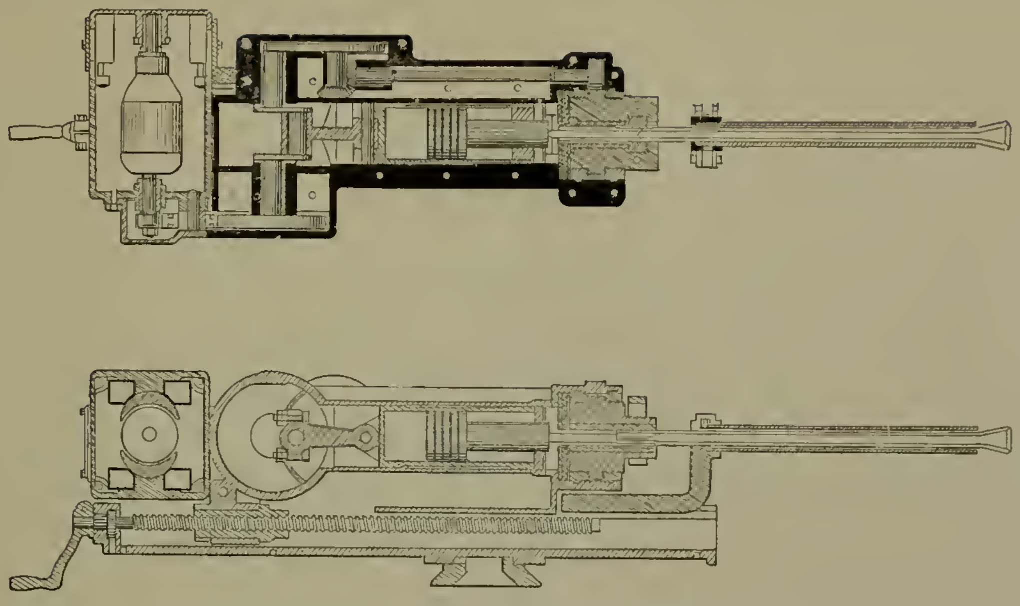


FIG. 10.—CROSS-SECTIONAL VIEWS SHOWING THE CONSTRUCTION OF THE BOX ELECTRIC DRILL MADE BY THE H. D. CRIPPEN MANUFACTURING COMPANY, NEW YORK

shows it mounted on a quarry bar for quarry work.

In Fig. 5 the drill is swung to one side so that the long steel bit which is in the rock may be taken out and a new one inserted in its place. The drill is then swung back into position and is in exact alignment. The hinge which permits of swinging the drill to either side is a distinctive feature of this type of drill.

To operate the drill at maximum speed requires 1½ horse-power, a 2¼-inch hole being drilled at the rate of 3 inches per minute in hard granite, or 30 inches per minute in soft sandstone. A depth of 20 feet can thus be reached. The drill weighs 245 pounds without the motor, or 345 pounds complete. Although attached directly to the drill body, the motor is so arranged that it may instantly be detached if desired.

As shown by the cross-sectional views in Fig. 10, the motor is mounted on the guides of the shell, and the armature is geared to a crank which is connected to the cross-head by means of a connecting rod. The cross-head is a cylinder in which is fitted the hammer of the drill. The hammer resembles the piston and rod of a steam engine, an air space being left between the piston of the hammer and the heads of the cylinder cross-head. Each end of the moving cylinder is filled with air at atmospheric pressure, and this being alternately compressed and rarefied, acts exactly as a spring, but without the wearing qualities of the latter.

To force the cuttings away, and thus keep the face of the rock always clean and exposed to the bit, a pump is provided for forcing water through a pipe which surrounds the drill bit, and delivering it under a high pressure at the cutting edge of the bit. The water tank provided with the drill holds 15 gallons, and as the pump is operated for only 10 minutes at 4-hour intervals, it needs refilling only once in the first half of the shift, and once in the second half.

Fig. 8 shows another type of percussion rock drill, operated by electric hammer blows. This equipment, although self-contained as regards the motor, has the hammer protruding. The motor is geared to a shaft carrying a pair of eccentrics which raises the hammer during a three-quarter revolution of the eccentric shaft, the blow being struck during the remaining quarter. Between 400 and 500 powerful hammer blows per minute are thus delivered to the bit of the drill.

FIG. 11.—PROPER ARRANGEMENT OF THE BOX ELECTRIC DRILL FOR TUNNELING OR STOPING WORK

The percussion drill shown in Fig. 12 is not self-contained as regards the motor, this part of the apparatus being mounted in a box and connected with the drill by a flexible shaft about 8 feet long, through which the power is transmitted. This drill is made by the Mine & Smelter Supply Company, of Denver, Col.

The Deitz electric rock drill shown in Fig. 9 and made by the F. M. Davis Iron Works Company, of Denver, Col., is also driven by an electric motor through a flexible shaft. One of the principal advantages claimed for this drill is that, as the piston is released from the driving mechanism at a certain point in each blow, the shock caused by striking the rock is not transmitted to the mechanism in any way, and the drill stands up to its work more firmly than would otherwise be the case. Releasing the piston in this manner also gives the maximum effect to the stroke. Another point urged in its favour is that a light spring may be used in place of a heavy one for transmitting the power, thus allowing the apparatus to run with less power when the drill steel is stuck in the rock, and therefore bringing less strain upon the mechanism at such times.

A 2-H. P. motor equipped with a speed controller is used for driving the Deitz drill. There is also provided a flexible shaft 6 feet in length, which is made reversible so as to enable the operator to reverse the shaft often and thus prolong the life of the core, as the breakage always comes at the motor end where there is the greatest strain. The core consists of a wound-wire cable, upon which roller bearings are placed for reducing the friction.

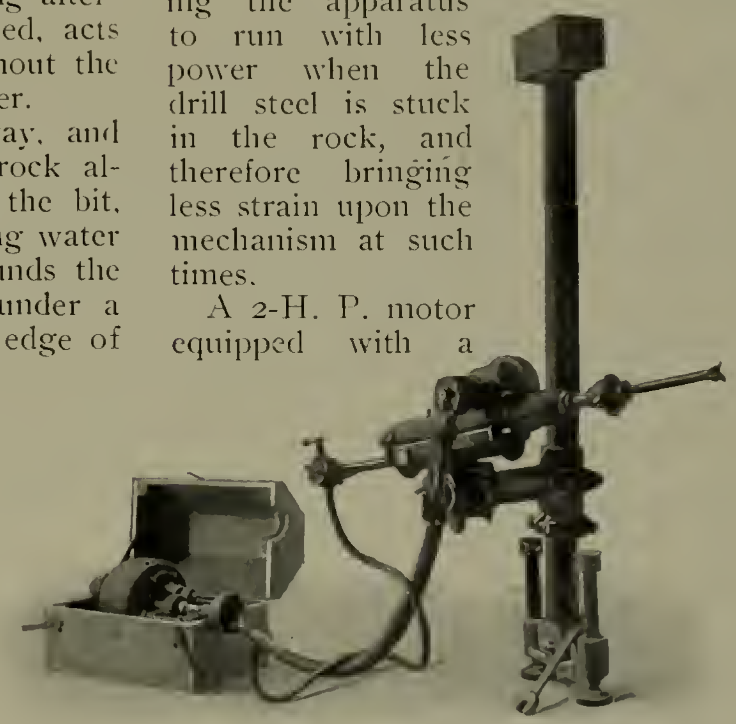


FIG. 12.—A PERCUSSION DRILL DRIVEN ELECTRICALLY THROUGH A FLEXIBLE SHAFT. MADE BY THE MINE & SMELTER SUPPLY COMPANY, DENVER, COL.

For all of the drills previously presented, motors of the direct-current type are used. These are generally designed to operate on 110, 220, or 550-volt circuits, unless otherwise specified. In case the only available

electric supply is an alternating current, it is advisable to install a motor-generator for transforming the alternating current to direct current, rather than use an alternating-current motor for driving the drill. The reason for this is that direct-current motors are better adapted to operate satisfactorily under the wide variations in speed necessary in rock drilling.

A PERCUSSION ROCK DRILL MADE BY THE GARDNER ELECTRIC DRILL & MACHINERY COMPANY, CLEVELAND, OHIO

A Producer Gas Power Plant

PRODUCER gas power was recently adopted by the Norton Emery Wheel Co. as an addition to their present steam plant at Worcester, Mass. The engine is of the horizontal, double-acting, heavy-duty type, built by the Westinghouse Machine Company, of Pittsburg, and gas is supplied by Loomis-Pettibone producers, using bituminous coal.

The new gas engine will be 500 B. H. P. rated capacity, direct connected to a Westinghouse 250-volt, 300-KW. generator, running at a speed of 150 revolutions per minute. This unit will operate in parallel with two belted steam units, the plant supplying current to various motor drives in the factory, and for lighting.

The engine will be of the tandem-cylinder, single-crank style, water jacketted throughout. Pistons will be supported practically clear from the cylinder by front, middle, and rear crossheads. All valves are located directly in the cylinder body in a vertical line, inlet at the top and exhaust at the bottom. A sensitive governing system of the relay type places each inlet valve independently under the direct control of the governor, by which arrangement close speed regulation is secured.

Similar engines of this type are now operating on the Warren & Jamestown Railway interurban system at Warren, Pa.; at the Carnegie Technical Schools, Pittsburg, Pa.; at the Standard Steel Car Company, Butler, Pa., and at the Carnegie Steel Works, Pittsburg. Engines of 3500 H. P. are now under construction for the latter plant, designed to use blast furnace gas.

At the Norton Company's plant the gas used will be a mixture of two gases, averaging about 125 B. T. U. per cubic foot. The producer process is intermittent, water gas being made during a short run, and "blast" or "air" being made while the producers are being blown preparatory to the succeeding water gas run. After a thorough cleansing in wet and dry scrubbers, the gas is sent to a holder of sufficient capacity to secure a thorough mixture of the alternating charges of the two different gases. In this case a 20,000 cubic foot holder will be used,—sufficient to run the engine for about twenty-five minutes.

In describing mining operations in El Oro, Mexico, H. E. West, in "The Mining Magazine" says that the use of synchronous motors in one stamp mill for driving the stamps has proved of marked benefit as uniformity of speed is an important matter to the cams of a stamp mill. A great saving has also been made by the use of electricity in various ways. In February a saving of $20,000 was obtained. The amount, moreover, of total mining expenses for the month of February was reduced to $5.01 (gold) per ton of ore treated in place of $6 and over for the previous month. This saving is due largely to the economy in power charges. The amount of cordwood burnt daily at the El Oro mine was fully 200 cords, whereas the consumption is now reduced to about 60 cords daily. Most of the steam at present is required for the main hoist. Several locomotives were always on the 60 kilometers of railroad hauling wood from the mountains to the mine for the twenty-six boilers in commission. This necessitated a large number of wood-passers, firemen, etc., at the mine, with some thousands in the woods, which now have mostly been dispensed with. The cost of cordwood delivered was about $7.50 per cord. The cost of steam power per H. P. was fully five cents (silver) and over. This cost has now been more than cut in half, and is more probably about one-third of the former cost.

Between Cologne and Bonn, in Germany, a direct-current railway is to be constructed, the voltage being 990, except at the terminals, where 550 volts are used. Two interpole motors, each of 130 H. P. capacity, will be placed on each car. The motors are of the four-pole type. Two sliding low trolleys are provided for each motor car.

Electrical and Mechanical Progress

Starting Up of an Allis-Chalmers Steam Turbine

A 5500-KW. steam turbo-alternator, built by the Allis-Chalmers Company, was recently started up in the Kent avenue power house of the Brooklyn Rapid Transit Company. The turbine and its direct-connected alternator were ready for operation on February 1, but the boilers, condensing apparatus, piping, etc, were not completed until late in March. While lying idle for nearly two months in an uncompleted station, the insulation of the generator windings naturally became damp, and therefore as soon as steam was available for running the turbine, it was started up at low speed to dry out the generator.

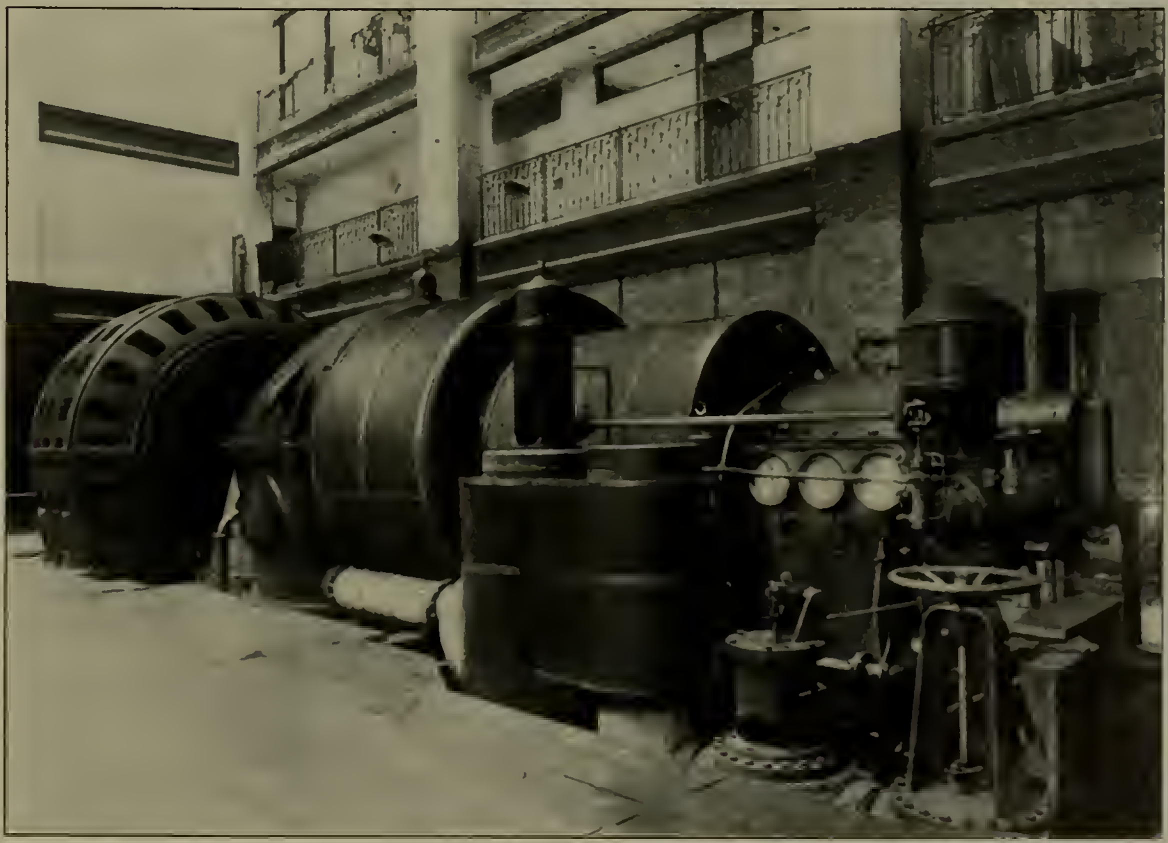
This drying-out process was going on when, on the morning of March 27, a mishap at another power house left the railway company short of power. The urgency of the situation was explained to the Allis-Chalmers representatives at about 10 o'clock, and they were asked whether they could help out with the afternoon load. Feeling a strong confidence in their apparatus, the Allis-Chalmers engineers decided to put the turbine into regular operation, notwithstanding the fact that it had never been under load, nor had it even been up to speed except when running unloaded at the West Allis shops.

Additional boilers were therefore fired up, and other hurried preparations made for starting. The turbine continued to run slowly until 12 o'clock to dry out the generator. It was then shut down, and the engineers proceeded with progressive tests of the insulation, testing up to such a point as they considered safe for the rated voltage of 6600, but not considering it wise to risk too high a test in view of the damp state of the generator.

The insulation tests were completed at 1:56 P. M., and the turbine was again started up, and run up to the full speed of 750 revolutions per minute for the first time since installation at the power house. At 2:30 P. M. the engineers, after carefully assuring themselves that everything was working well, reported that they were ready, and an increasing load was immediately put on until at 3:05 the turbine was carrying a little over 3000 KW., which was all that the railway company needed at that time.

As more load was called for, it was put on, and at 3:45 P. M. the unit was carrying over 4000 KW. On the following day the load ran up to over 5000 KW., and on the succeeding day it reached 7000 KW., the turbine taking heavy loads during the morning and afternoon peaks, and running until late each night.

On March 30, the other apparatus of the Transit Company being again in working order, an opportunity was given to lay off the turbine and open it up for examination, and here



A 5500-KW. STEAM TURBINE GENERATING UNIT BUILT BY THE ALLIS-CHALMERS COMPANY, OF MILWAUKEE, WIS., FOR THE WILLIAMSBURG STATION OF THE BROOKLYN RAPID TRANSIT COMPANY. THIS IS THE FIRST COMPLETE TURBINE UNIT FROM THE ALLIS-CHALMERS SHOPS

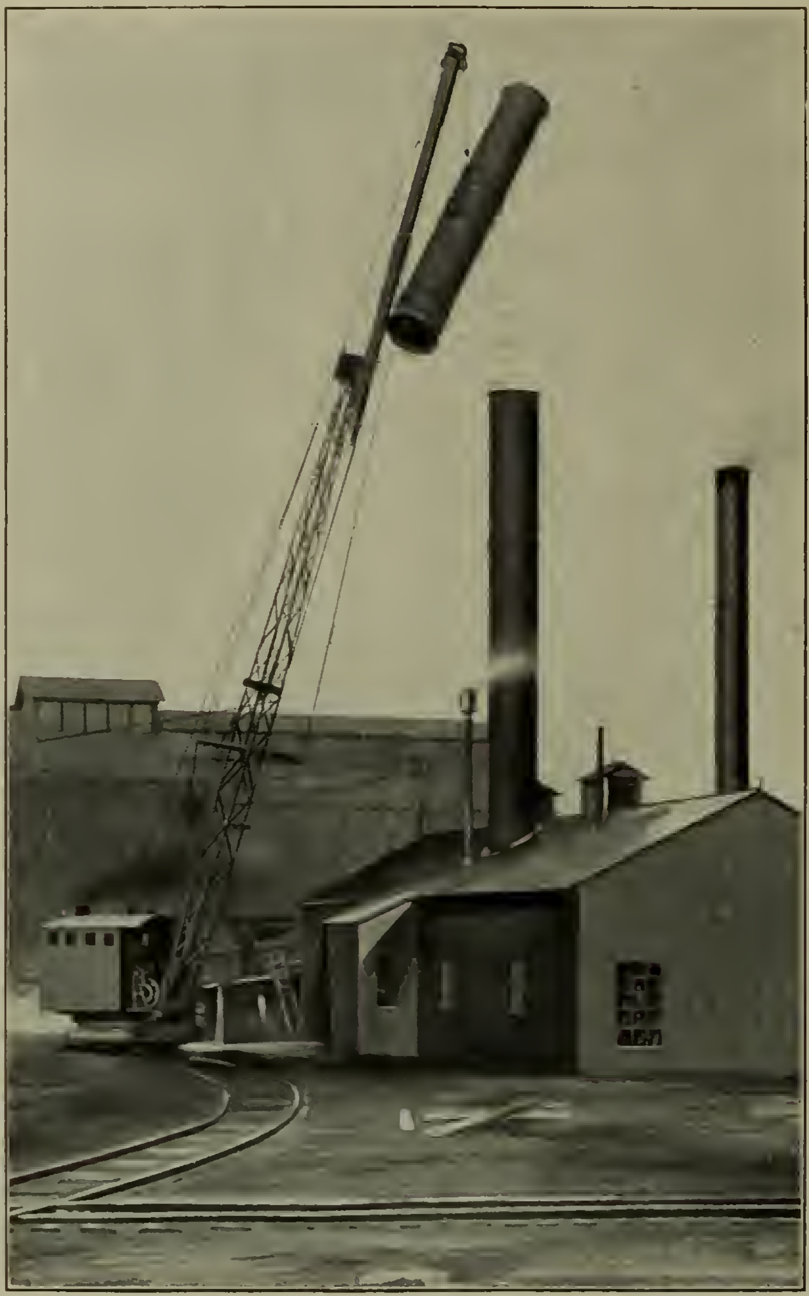
an agreeable surprise awaited the engineers. Heretofore, in the operation of steam turbines, in numerous cases the turbine cylinders have slightly arched upwards under the effect of superheated steam, on account of the top of the cylinder expanding more than the bottom, and in a considerable number of instances this has caused the rotating blades to come in contact with the cylinder and be ripped out.

In the Allis-Chalmers design it was sought to overcome the distortion of the cylinder by such a distribution of the metal as to cause nearly equal expansion of the top and bottom of the cylinder, but at the same time the turbine drum was placed slightly above the center of the cylinder to assist in preventing contact of the blades in case of distortion. When the turbine was opened up, however, it was found that the compensation for distortion had been slightly overdone, and the cylinder had sagged a small amount and this, together with the high position of the drum, had caused the blades to rub hard for nearly a third of the length of the turbine. With the older types of construction such contact would immediately have made itself manifest by the noise of the rubbing blades and the blades would have been ripped out before the turbine could be stopped. In the Allis-Chalmers turbine, however, there had been, while in operation, no indication of the blades rubbing and no damage whatever had been caused; the only sign of contact having taken place was a slight wearing away of the flanges of the channel-shaped shroud ring, which protects the tips of the blades in the Allis-Chalmers construction.

Besides the blades which rubbed on account of the slight distortion of the cylinder, a few rows of blades at the inlet end of the turbine were found to have rubbed on sand and other dirt which had gotten into the turbine from the steam pipes, but in this case also the shroud ring prevented all damage.

The only precaution taken before starting up again to help carry the Coney Island load on April 1 was to lower the drum a few thousandths of an inch at each end. So far as known this has prevented all further rubbing, and the turbine has been in daily operation ever since, and has not again been opened.

This is the first turbine turned out complete in the Allis-Chalmers shops. A turbine which has been in operation for some time at Utica was built on the same system for the Allis-Chalmers Company by Messrs. Willans & Robinson, of Rugby, England, and a number of other turbines of Allis-Chalmers' own make are being erected and will shortly be started.



A LOCOMOTIVE CRANE BUILT BY THE BROWNING ENGINEERING COMPANY, CLEVELAND, OHIO, CARRYING A SECTION OF A SMOKESTACK WEIGHING 4½ TONS, AT A RADIUS OF 25 FEET

A Locomotive Crane for Handling Heavy Material

ONE of the many uses to which the steam locomotive cranes built by the Browning Engineering Company, of Cleveland, Ohio, may be put, is shown in the accompanying illustration. Here a 100-foot smokestack is being erected for the power station shown, and the crane is working at a radius of 25 feet. The section of the smokestack which is being carried by the crane weighs 4½ tons.

The long boom arrangement was fitted up especially for the occasion by tying a heavy 40-foot timber on the 65-foot iron boom, allowing 10 feet for lap.

The motive power of this locomotive crane is steam. The machine is built for service on a standard gauge track, which allows it to be hauled great distances. It has a draw-bar pull equal to that of an ordinary yard locomotive.

Among the other uses for which locomotive cranes are built by the company, either with or without a grab bucket or a hook block, are the handling of coal and ashes, light wrecking, switching cars, heavy hauling, hoisting stone and earth from excavations or placing stone in foundations, handling sand, gravel, poles, lumber, heavy castings, slag, iron, and sheet metal.

Recent Installation of Cooper Hewitt Mercury-Vapour Lamps

AMONG prominent recent installations of mercury-vapour lamps, manufactured by the Cooper Hewitt Electric Company, of New York, are those at the enlarged Newark works of the Westinghouse

Electric & Manufacturing Company, where 470 lamps are in use; at the new model factory of the J. L. Mott Iron Works, at Trenton, equipped with 113 lamps; at the new Baring Cross shops of the St. Louis, Iron Mountain & Southern Railroad, at Argenta, Ark., equipped with 105 lamps, and at the new Attica works of the Westinghouse Machine Company, where 86 lamps are used. Five of the largest river piers in New York are lighted by them. All the United States Government currency and international revenue stamps are printed under their light in the Bureau of Engraving and Printing at Washington, and the Automobile Club of America will use 96 lamps in its new garage building in New York.

Other interesting installations are for the lighting of the presses and make-up tables in the new building of the New York Times, with 48 lamps; of the offices and press rooms of the Butterick Publishing Company, with 120 lamps; and of the polishing and action departments of the large new piano works of William Knabe & Son, Baltimore.

Notable examples of office lighting are to be seen also at the Washington Post Office, where 30 lamps, requiring 105 amperes in all, are in use in the high-vaulted mailing room, 100 by 200 feet, on the ground floor, in the place of 1000 incandescent globes requiring 500 amperes, with which the room was formerly lighted; at the New York Post Office, 53 lamps are in service in the carriers' and foreign money order departments, and at the New York auditing offices of the American Tobacco Company, 48 lamps light the rooms in which several hundred bookkeepers are employed.

All but a few of the installations of the past year have been with the 300-candle-power type "H" and the 700-candle-power type "K" direct-current lamps, but the 425-candle-power type "C" lamp, for alternating-current circuits, recently put upon the market, is now being delivered for various installations where the advantages of mercury lamp lighting have not before been possible.

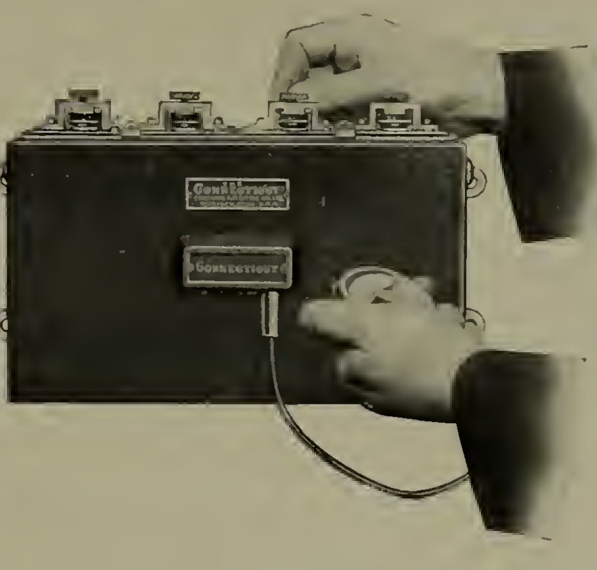
The "H" lamps are generally operated in series—two in series on circuits of from 98 to 122 volts, or four in series on circuits of from 196 to 244 volts. The "K" lamps are operated singly on circuits of from 98 to 122 volts, and two in series on a 196-244 voltage. Series lamps are arranged with extra shunt resistances so that either lamps of a pair in series may be operated singly if desired.

Both types of the direct-current lamps are run at $3\frac{1}{2}$ amperes, two "H" lamps in series on a 110-volt circuit consuming 385 watts, one "K" lamp installed singly on a circuit of the same voltage consuming the same current, and two "K" lamps in a series on a 220-volt circuit consuming 770 watts. The new type "C" alternating-current lamp consumes 275 watts on either 110 or 220-volt circuits, or 0.64 watt to a candle-power.

A Current Indicator for Automobile Spark Coils

An indicator, manufactured by the Connecticut Telephone & Electric Company, of Meriden, Conn., for measuring the strength of current in an automobile spark coil, is shown in the annexed illustration. Such an instrument is essential to the proper adjustment of the coil vibrator, as the sound affords little indication of the amount of current passing.

If, in adjusting a coil, the tension on the vibrator is increased, the amount of current passing is also increased, and in the majority of cases coils are adjusted to consume more current than is actually required to do the work intended. Hence batteries give out, or, in the case of storage batteries, they must be recharged at shorter intervals than would otherwise be necessary.



A CURRENT INDICATOR FOR AUTOMOBILE SPARK COILS. MADE BY THE CONNECTICUT TELEPHONE & ELECTRIC COMPANY, MERIDEN, CONN.

A properly constructed coil should be designed to take a given amount of current to secure desired results. If, then, the coil is correctly made and the proper amount of current used to operate it, the result will be the almost total elimination of battery troubles. With more current than is necessary also, the more will sparking and timer contacts burn, causing wear and improper timing.

The device illustrated consists of a special form of indicating meter, to which is attached a double conducting cord and metallic circuit plug. In order to test the amount of current being used in the spark coil, the running plug is removed and the indicator plug inserted.

New Catalogues

Locomotive cranes, built by the Wellman-Seavey-Morgan Company, of Cleveland, Ohio, are dealt with in a catalogue recently issued. The cranes are used for a great variety of work about manufacturing plants, iron and steel works, machine shops, railway shops and yards, docks, quarries and stone yards, on contractors' work, and about paper mills, logging camps, plantations, and other establishments where bulky or heavy materials are to be handled. When equipped with the company's automatic bucket, they will handle various loose materials such as coal, iron ore, sand, ashes, gravel, granulated cinders, ballast and crushed limestone, loading and unloading from open top cars, transferring from barges to cars or wagons, handling to and from storage piles and to bins, pockets, conveyors, and boiler houses.

The Allis-Chalmers Company, of Milwaukee, Wis., have published a new bulletin relating to their alternating-current generators of the water-wheel type. Standard machines of this class are of either horizontal or vertical type. The bulletin contains tables, giving the output, speed, and voltage of these machines and also some excellent illustrations of hydro-electric plants.

Direct-current motors of from 3 to 45 horse-power, and direct-current generators of from $2\frac{1}{2}$ to 40-KW. capacity, built by the Crocker-Wheeler Company, of Ampere, N. J., are illustrated and described in a bulletin recently issued. Various kinds of machines driven by these motors are also illustrated, among them being a drill, an 8-foot boring mill, a planer, a facing machine, an axle lathe, a portable hoist, a shaper, an engine lathe, a vertical milling and drilling machine, a vertical slotter, and a roll lathe.

"Something New in Motor Drives" is the title of a new leaf sent out by the Gisholt Machine Company, of Madison, Wis., for binding with the others previously issued. The novelty referred to by the title is the

manner in which the motors are now attached to Gisholt tools for driving them. In a horizontal boring and drilling machine illustrated, for example, the motor is mounted directly on the extended base, the armature shaft extending into the bed under the headstock, where it is connected to the spindle gear through a silent chain. The controller is mounted so as to be easily accessible from either side of the machine.

Belt conveyors for handling excavated earth and rock, and concrete materials, are well illustrated and described in a catalogue recently issued by the Robins Conveying Belt Company, of New York. Most of the illustrations show the conveyors as actually installed in different plants, and in many of the views the conveyors are shown in operation.

The Murray Iron Works, of Burlington, Iowa, recently sent out an attractive catalogue treating of their Corliss engines, high-pressure boilers, and complete power plant equipments. The various details of the engines are shown and described separately. The boilers shown are of the tubular, the water tube, and the internal-furnace type. The complete power plants equipments furnished include engines, boilers, heaters, pumps and piping. The illustrations in the pamphlet are excellent and the whole is of a high order typographically.

Hold-fast lamp guards, manufactured by the Hold-Fast Lamp Guard Company, of St. Louis, are illustrated in a leaflet recently issued. The guards are made in two sizes, one for regular sockets, and one for weather-proof sockets, and are held by being fastened on the sockets of the lamps.

The Buckeye Electric Company, manufacturers of the "Buckeye" lamp, of Cleveland, Ohio, have sent out a very attractive folder entitled "Sidelights on the Buckeye." The title is attractively illustrated in colours on the cover by showing an Oriental woman holding an incandescent lamp so that its rays fall upon the head of a beautiful stag. The interior of the folder shows a full-size "Buckeye" 110-volt, 16-candle-power incandescent lamp; a factory, a street car, a theater sign, a weaving room in a silk mill, a dining room, and several exterior illuminations, in all of which "Buckeye" lamps are used.

Cold-saw cutting-off machines for rapidly cutting off metal of different shapes are well illustrated in a new catalogue issued by the Newton Machine Tool Works, of Philadelphia, Pa. These machines are adapted to the cutting of round and square stock, I-beams, and channel bars, also armour plate, nickel steel and gates or risers on steel castings.

An announcement in the form of an attractive pamphlet was recently sent out by the Arnold Company, of Chicago, regarding their new offices in the Borland Building, at 181 La Salle Street, Chicago, where they occupy the entire sixteenth floor. Two coloured views of the Borland Building are shown,—one an exterior view, and the other a view of the entrance hall. In another part of this issue of THE ELECTRICAL AGE an account is given of the extensive activities of these engineers and constructors.

A very unique and attractive catalogue is that issued by the Electric Cable Company, of Bridgeport, Conn., and devoted to "Voltax," the new high-potential insulating material. The results of the tests made by the Electrical Testing Laboratories, of New York, on samples of wire wrapped with cotton tape impregnated with "Voltax," are given in this booklet.

The Pittsburg Transformer Company, of Pittsburg, Pa., have sent out a leaflet describing their winding department. Illustrations of a completed transformer coil, and of the insulation used between the primary and secondary windings of their transformers, are given in the leaflet. On the last page of this leaflet advertisements of positions wanted, help wanted, or of machines for sale or exchange may be inserted by anyone without charge.

The Brill noiseless brake hanger is dealt with in a new catalogue issued by the J. G. Brill Company, of Philadelphia, Pa. The brake hanger is shown alone, and also fitted to a Brill truck. It is self-adjusting, and is claimed to perform its duty for two years without requiring attention.

"Electric Signs" is the title of a new booklet sent out by the Metropolitan Engineering Company, of Brooklyn, N. Y. The various popular types of electric signs made by this company are well illustrated in this publication. As the illustrations are self-explanatory, but few facts and figures regarding their construction and dimensions are given. On the last page of this booklet some interesting information is given regarding the cost of operating various types of electric signs.

A new bulletin, recently sent out by the Fort Wayne Electric Works, of Fort Wayne, Ind., illustrates and describes small direct-current generators, many views and explanations being given regarding the construction of the various parts. An instruction book on the Fort Wayne multiphase and induction integrating wattmeters is also worthy of mention. Aside from a general description of the parts of this meter, its installation and operation are thoroughly described with the aid of numerous diagrams. In a bulletin devoted to their multiphase, revolving-field, belted generators, many excellent illustrations show the parts of the generator, the exciter, and the rheostat.

Two new publications have been issued by the H. T. Paiste Company, of Philadelphia, Pa. One of these is devoted to the brass cap and porcelain styles of Paiste attachment plugs, a special point being made of their neat appearance. The other publication is a price list, accompanied by a discount sheet.

The General Electric Company, of Schenectady, N. Y., have issued a number of new bulletins and flyers. Of the former, one is devoted to their high-efficiency, high candle-power incandescent lamp with different forms of reflectors; another, to their direct and alternating-current, automatic, carbon break circuit breakers; and a third, to their straight air brake equipments. Of the two new flyers, one treats of the General Electric multiplex lightning arresters of the shunt-resistance, multigap type, and the other of universal sockets, shades, and portable lamps. A new 43-page catalogue, illustrating and describing fan motors for 1906, has also been sent out. Technical details have been omitted in describing the new design, but these will be supplied upon request.

In the item describing the folder entitled "Under the Gates of Babylon," in the March number of THE ELECTRICAL AGE, E. T. Smith & Co., of Cleveland, were given as the manufacturers of "Buckeye" incandescent lamps. As the Buckeye Electric Company, of Cleveland, are so well known as the makers of these lamps, a correction of the error seems hardly necessary, yet we make it cheerfully, nevertheless. The folder is certainly a unique one, and ought to impress the name "Buckeye" on the mind of the reader.

Personal

James Rawle has been elected president of the J. G. Brill Company, of Philadelphia, to succeed the late G. Martin Brill. Up to the time of the latter's death Mr. Rawle was the treasurer of the company. His promotion necessitated a general election of officers of the Brill Company, resulting as follows: Treasurer, Edward Brill; secretary, M. Herman Brill; assistant treasurer, Edward P. Rawle; vice-president, John A. Brill; general manager, Samuel P. Curwen; assistant secretary, William H. Heulings. Mr. Rawle is a Philadelphian and graduated in 1861 from the civil engineering course of the University of Pennsylvania. He was for many years in the service of the Pennsylvania Railroad, and entered the old firm of J. G. Brill & Son in 1872. M. Herman Brill, the new secretary, is the only son of the late president. Edward P. Rawle is a son of James Rawle, the new president.

Charles A. Mudge, formerly chief engineer of the railway department of the Allegemeine Elektricitäts-Gesellschaft, of Berlin, has been appointed consulting engineer of the Electro-Dynamic Company, of Bayonne, N. J. Mr. Mudge's work will be in connection with the design of high-voltage, interpole, direct-current motors.

W. Rawson Collier, until recently with the Georgia Railway & Electric Company, of Atlanta, now holds the position of factory manager of the Electric Manufacturing & Equipment Company, manufacturers of telephone appliances, in the same city.

H. W. Buck, the well-known electrical engineer and head of the electrical department of the Niagara Falls Power Company, will enter the service of the engineering firm of Viele, Cooper & Blackwell, of New York City. Mr. Buck will also continue his connection with the Niagara Falls Power Company, making his headquarters in New York City.

Graham Smith, formerly in charge of Westinghouse exposition and convention publicity, later as the New York Westinghouse press representative, and recently engaged in advertising work under his own name, will sail very soon for a journalistic tour of several months abroad. On his return, he will assume the direction of the eastern advertising interests of several prominent corporations of the Middle West and West, with an office in the Fuller Building, New York, and will make a specialty of the preparation of industrial books of the higher class. Mr. Smith was born in Buffalo on August 24, 1878, and was graduated in 1900 from Harvard College, with high honours in English. After a year's travel, he spent three years on the staff of the New York "Evening Sun," as news reporter, assistant city editor, real estate editor, and writer on financial topics. The latest example of his literary work is the souvenir book descriptive of the comprehensive Westinghouse exhibits at last year's International Railway Congress at Washington.

W. S. Hopkins has resigned as general superintendent of the Columbus Railway and Light Company, being succeeded by L. G. White, acting assistant superintendent. Mr. Hopkins will become chief engineer of the railway holdings of Clark & Company, Philadelphia, Pa., but will continue to make Columbus his headquarters.

Frederick C. Fraentzel, mechanical engineer and patent expert, and George D. Richards, attorney and counsellor-at-law, beg to announce that they have formed a copartnership for the practice of patent and trade-mark law, the soliciting of American and foreign patents, and mechanical engineering, with offices corner Broad and Mechanic Streets, Newark, N. J., and at 50 Nassau Street, New York. Mr. Fraentzel is a graduate of Stevens Institute of Technology, and has been established in the practice of patents and as a mechanical engineer at the above Newark address since 1885, and Mr. Richards, who is a graduate of New York University, has been associated with Mr. Fraentzel for many years.

William Clegg, Jr., who has been special agent of the Westinghouse Electric & Manufacturing Company in their St. Louis territory, was recently appointed acting manager of the St. Louis office. D. E. Webster, formerly manager of the office, was transferred to a position in the Chicago sales office of the company. J. S. Tritle was appointed acting manager of the new district office opened by the Westinghouse Electric & Manufacturing Company in the New England building, Kansas City, Mo. Mr. Tritle was formerly connected with the St. Louis office of the Westinghouse Electric & Manufacturing Company.

H. Freyn, formerly engineer of the gas engine department of the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, is now with the Illinois Steel Company, of South Chicago, Ill.

During the last month the ranks of those journeying across the Atlantic have been increased by a number of electrical engineers. John W. Lieb, Jr., of the New York Edison Company, sailed with Mrs. Lieb during the first week in May; Louis A. Ferguson, R. C. P. Holmes and P. Junkersfeld, of the Chicago Edison Co., and C. T. Wilkinson, of the General Electric Co., sailed the following week, and Charles L. Edgar, of the Boston Edison Company, sailed on May 22. Dr. W. R. Whitney, of the General Electric Company, also went abroad late in April.

R. Borlase Matthews, formerly connected with the National Electric Company, of Milwaukee, is now electrical engineer for the Edison Electric Light and Power Company, of Amsterdam, N. Y.

Trade News

The American Vitrified Conduit Company, manufacturers of vitrified salt glazed underground and interior conduits, announce the removal of their New York offices to the Fuller Building, Broadway, Fifth Avenue and Twenty-Third Street.

The Standard Underground Cable Company, of Pittsburg, announces that on account of the recent fire in San Francisco, its offices in that city are now at Bacon block, Oakland, Cal.

The H. B. Camp Company, manufacturers of vitrified clay conduits, and formerly located at 170 Broadway, New York, are now in the Fuller Building, Broadway, Fifth Avenue and Twenty-Third Street.

The Power & Mining Machinery Company, of Milwaukee, Wis., have recently closed contracts for their Loomis-Pettibone gas generating plants for an aggregate of approximately 12,000 horse-power. These include an installation for the Pittsburg Plate Glass Company at their Crystal City, Mo., plant to produce gas for operating a large Allis-Chalmers gas engine; the Norton Emery Wheel Company, Worcester, Mass., for operating Westinghouse gas engines; the Charlotte Consolidated

Construction Company, Charlotte, N. C., for operating Snow gas engines in connection with street railway work, and an increase in the present installation at Sayles' Bleacheries, Sayllsville, R. I., for the operation of American-Crossley gas engines. These producers will be operated on bituminous coal, but are capable of gasifying a great variety of fuels, and their adaptability to the use of different fuels without any alterations being made in the apparatus enables the users to change instantly from one to another, and to use the most economical fuel that is available. Loomis-Pettibone plants of more than 150,000-horse-power capacity, have been installed, and are now in operation in this and foreign countries.

The Metropolitan Engineering Company, manufacturers of electric signs, have removed their factory and general offices to 1250 Atlantic Avenue, Brooklyn.

The George H. Gibson Company, advertising engineers, Park Row building, New York City, which conducts the advertising of a number of the leading machinery manufacturers, has recently taken up the advertising of inventions by mail. The company acts as commission agents in the selling of inventions, and uses personal representation and correspondence in bringing about a sale. The three members of the organization are engineers with practical experience in civil, mechanical, mining and electrical work, and have made, patented and sold inventions of their own. Their clients' inventions are presented in a bulletin, entitled "Engineering and Manufacturing," which contains, in addition to descriptions of several new inventions, articles of interest to manufacturers and inventors.

The Abner Doble Company, of San Francisco, Cal., are sending out the following notice:—"During the recent San Francisco fire, we suffered some loss, our offices and shops being burned, but we are already resuming business on a larger scale than ever before. We have opened temporary offices at 2611 Broadway, San Francisco, where the business of the company is being conducted for the present. We also have a branch office in Oakland, at 668 Broadway. We have now under construction large and new permanent shops and warehouses at Seventh and South Streets, in the Potrero district, where we will have the most completely equipped works on the Pacific coast. By May 15 part of our manufacturing establishment will be running full force, and within a very few weeks our entire plant will be in complete operation. We lost in the fire some of our correspondence and drawings. In order to check up our files and make our records complete, we should like to have you send us as soon as possible copies of all recent correspondence with you that refers to work which has not been closed up. We should also like to have copies of all drawings and blue prints sent you and sent by you to us before the fire. Our organization is intact, and we are now ready to take orders and to carry on our business as before. Your efforts in helping us to complete our files will assist us materially and will be very greatly appreciated."

The Electric Properties Company

JOHN F. WALLACE
President, the Electric Properties Company, New York.

THE Electric Properties Company, incorporated May 10 under the laws of the State of New York, with a capital of $6,000,000 preferred and $6,000,000 common stock, has been organized to acquire, finance and develop properties, either whole or in part, especially those in which electricity plays the principal part, such as power, electric traction and electric lighting enterprises, and to invest and deal in and to guarantee the securities of corporations operating such properties. It will also conduct, through Westinghouse, Church, Kerr & Company, all of whose capital stock is owned by the new company, a general engineering and construction business. It may also issue collateral trust bonds secured by the pledge of securities acquired in the course of business.

The purposes of the company, as mentioned above, will be mainly financial. It is not intended to make any changes in the organization or personnel of Westinghouse, Church, Kerr & Company, whose operations have been highly successful, and they will continue to be conducted under the efficient administration of Walter C. Kerr, president.

While the Electric Properties Company will avail itself of the engineering and construction organization of Westinghouse, Church, Kerr & Company, it will also use other engineering organizations or independent consulting engineers as circumstances may require. One of the objects of the new company will be to co-operate with vested interests, such as railways and other public service companies in the development of properties for their account, and either temporarily or permanently assist in financing such properties.

The great rapidity with which the uses of electricity are being extended, not only in the creation of new enterprises, but in changing the character of existing enterprises, will, it is believed, afford constantly increasing opportunities for the profitable investment of capital.

John F. Wallace has been selected as president of the new corporation, and two vice-presidents will be elected at the first meeting of the board of directors.

The following gentlemen constitute the directorate, all of whom will be actively interested in the conduct of the business of the Electric Properties Company:—

Charles H. Allen, vice-president Morton Trust Company, New York; Paul D. Cravath, Cravath, Henderson & De Gersdorff, New York; H. D. Giddings, New York; N. W. Halsey, N. W. Halsey & Co., New York; George C. Smith, vice-president Security Investment Company, Pittsburg; John A. Spoor, president Union Stock Yard & Transit Company and president Chicago Junction Railway Company, Chicago; Moses Taylor, Kean, Van Cortlandt & Co., New York; E. G. Tillotson, vice-president Cleveland Trust Company, Cleveland; F. D. Underwood, president Erie Railroad Company, New York; R. B. Van Cortlandt, Kean, Van Cortlandt & Co., New York; John F. Wallace, president Electric Properties Company, New York; Geo. Westinghouse, president Westinghouse Electric & Manufacturing Company, Pittsburg.

The headquarters of the company will be at 111 Broadway, New York.